# Part 4:

# Management Approaches and Tools

# CURRENT MANAGEMENT OF WILD RICE HABITAT BY THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES

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## ABSTRACT

The Minnesota Department of Natural Resources was initially charged with the management of wild rice (*Zizania palustris*) in 1939. Since water depth has long been recognized as one of the most important limiting factors of wild rice abundance in Minnesota, the majority of habitat management efforts have focused on lake levels. A preliminary 1999 survey of state, federal, and tribal resource managers identified beaver dam removal and water level management as the primary management activity on more than 60% of the managed basins. Wild rice seeding, bog removal, and fish barriers were applied on a relatively limited number of managed basins. Like other natural resource management agencies in Minnesota, the Minnesota Department of Natural Resources has both an intense interest in wild rice and limited human resources and funding for management.

## INTRODUCTION

In 1939, the Minnesota State Legislature charged the Minnesota Department of Natural Resources (MNDNR), then the Minnesota Department of Conservation, with the responsibility of managing Minnesota's wild rice (*Zizania palustris*) resource (Moyle 1969). Although much of the attention through the years has focused on harvest regulations, the MNDNR has also actively managed habitat for wild rice. This paper reflects preliminary data collected from state, federal, and tribal resource managers by the MNDNR Region 3 Wildlife Resource Assessment Unit concerning the distribution and management of wild rice in Minnesota (Drotts et al., this volume). Although the authors both recognize and appreciate that wild rice management is carried out by many different agencies, the primary focus here is on the activities of MNDNR wildlife managers.

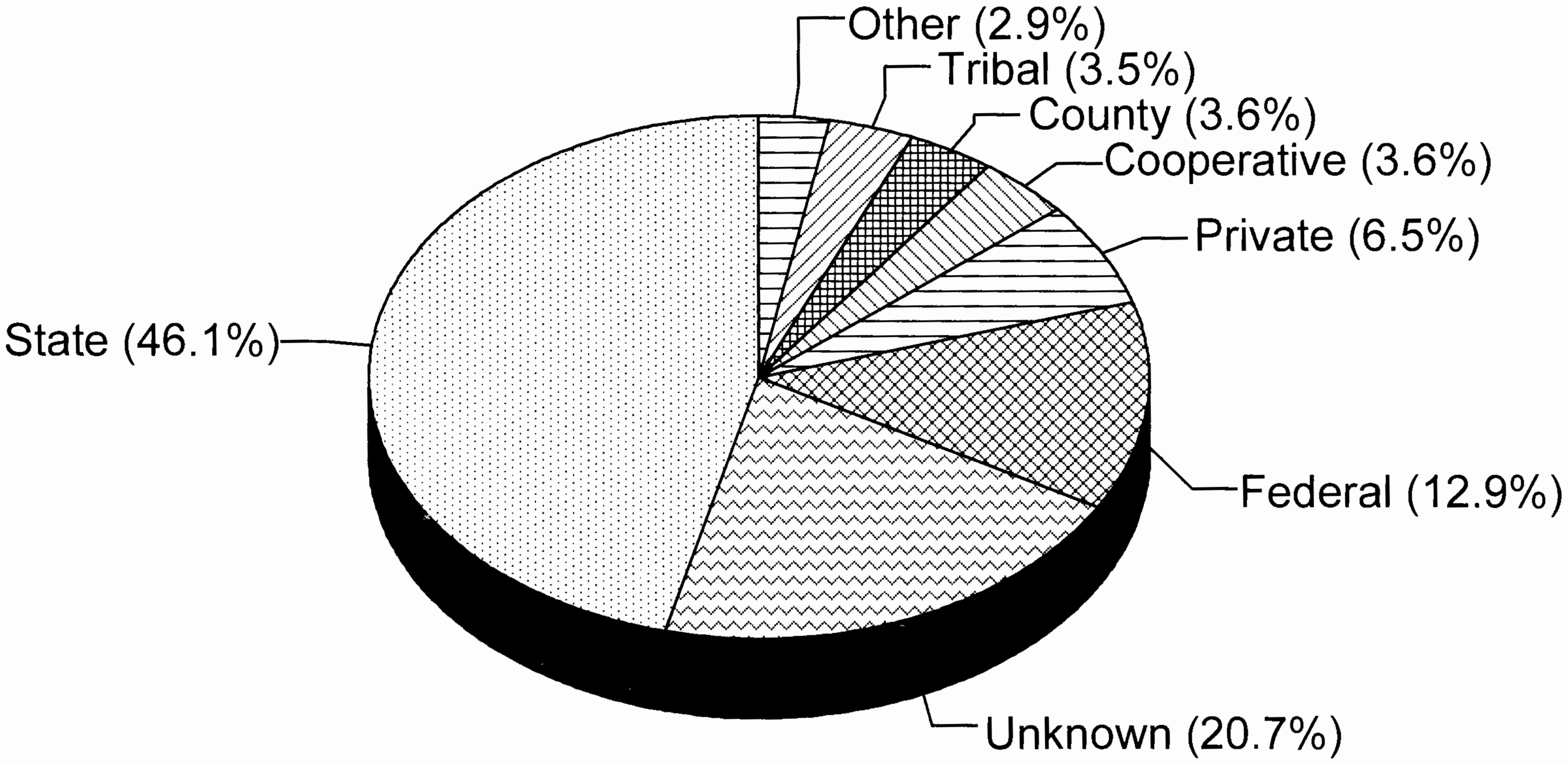
## RESULTS

More than 600 lakes and impoundments have been identified in Minnesota with occurrences of wild rice. Management promoting wild rice growth occurs on 310 of these basins. Figure 1 illustrates the breadth of the interest in wild rice. State, federal, tribal, and local governmental agencies are all involved at some level of management. It should be noted that Figure 1 represents the results of the preliminary survey conducted by the MNDNR and may underestimate some categories of respondents due to nonresponse bias. The MNDNR actively manages about 143 lakes and impoundments for wild rice production, primarily through local wildlife staff efforts.

The type of management occurring includes water level control, beaver dam removal (BDR), seeding, and bog removal. (See Figure 2.) Nearly a third of the basins were identified as being managed, but the type of management was not specified. The category of "other" includes some management activities not necessarily directly related to wild rice and fish barriers.

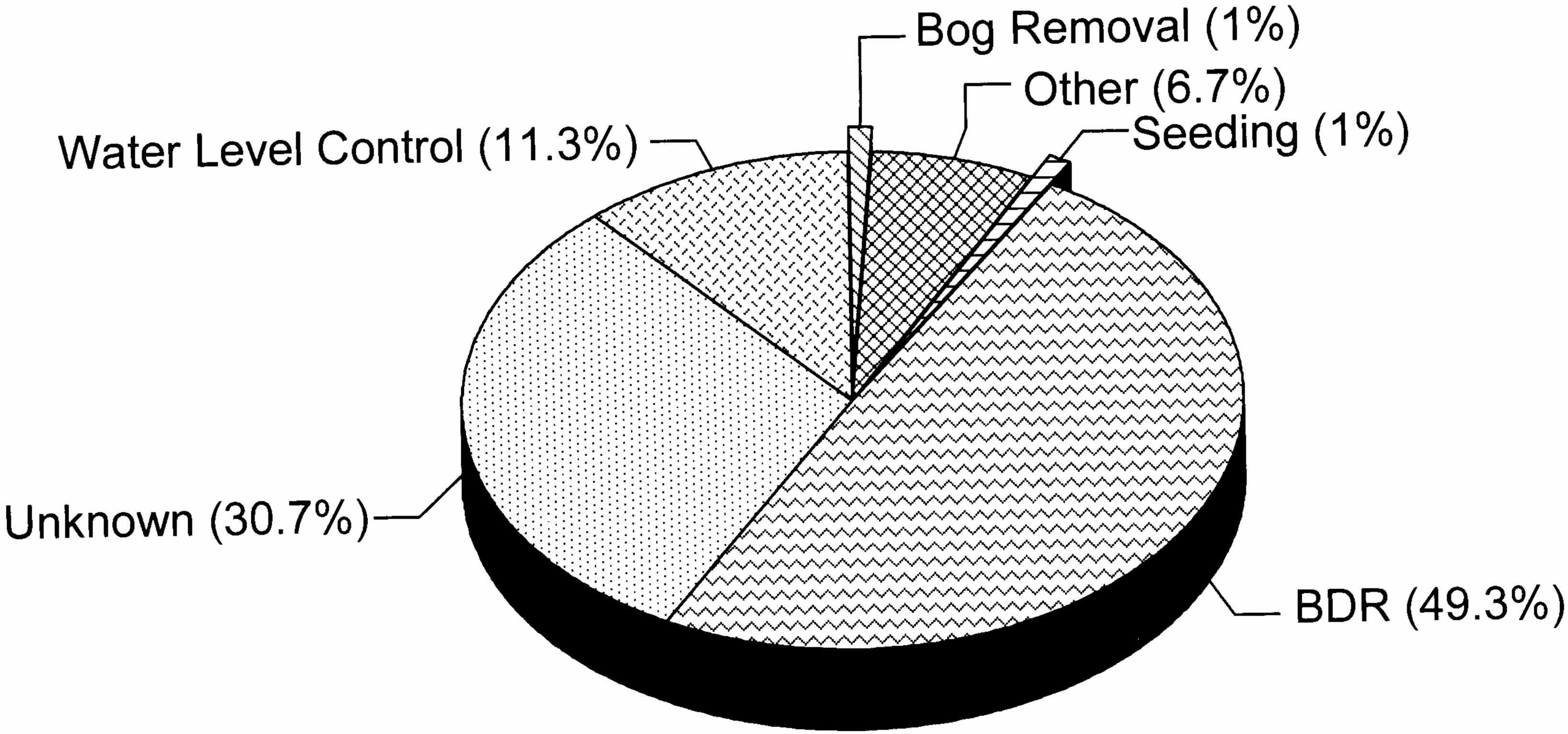
Although much of the wild rice range in Minnesota occurs outside of heavy rough fish infestation areas, carp have been associated with wild rice declines in the southern half of the state since the 1940s (Moyle 1942). Effective fish barrier designs can be physical, mechanical, or electrical. Nearly all of the current designs except electric weirs require some degree of fall (generally more than .91 m) at the

# Figure 1. Wild Rice Lake Managers



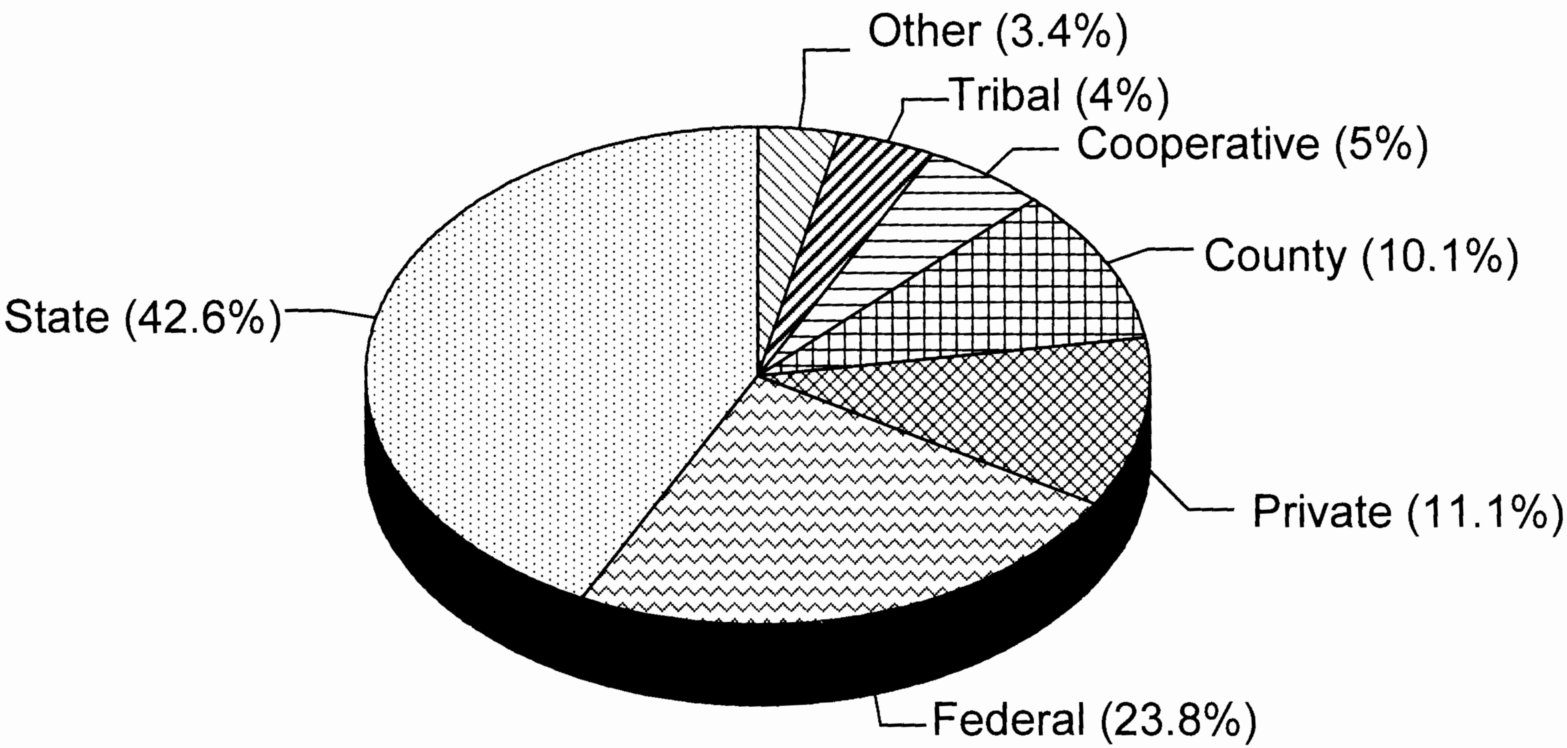

Based on preliminary 1999 data, 310 managed basins.

# Figure 2. Wild Rice Lake Management Types




Based on preliminary 1999 data, 310 managed basins.

# Figure 3. Wild Rice Lake Outlet Ownership




Based on preliminary 1999 data, 618 basins.

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# WILD RICE MONITORING AND ABUNDANCE IN NORTHEASTERN MINNESOTA (1998)

Darren J. Vogt

## ABSTRACT

The 1854 Authority is an inter-tribal natural resource agency governed by the Bois Forte and Grand Portage Reservation Councils. The organization is charged to preserve, protect, and enhance off-reservation treaty rights. The 1854 Authority's wild rice program aims to improve knowledge of wild rice ecosystems to lead to better management, protection, and restoration of viable wild rice waters in the 1854 Ceded Territory while promoting cooperative efforts between tribal and non-tribal agencies. A survey to document wild rice presence and water body characteristics has been conducted on historic rice waters from 1996 through 1998. Fifty-two lakes/rivers within the Territory have been surveyed during this period. A wild rice monitoring program was initiated on nine lakes in 1998. Water level, temperature, and quality were recorded throughout the growing season. Wild rice density and area were estimated and an abundance index was calculated for each lake. In 1998, Breda, Campers, and Stone (a) Lakes contained excellent wild rice crops; Cramer, Marsh, and Round Island Lakes contained good wild rice crops; and Big Rice, Cabin, and Stone (b) Lakes contained fair to poor wild rice crops. The same waters will be monitored in future years to obtain comparable information. This paper summarizes results from the first year of wild rice monitoring.

## INTRODUCTION

The 1854 Authority's goal is to improve knowledge of wild rice ecosystems to lead to better management, protection, and restoration of viable wild rice waters in the 1854 Ceded Territory of northeastern Minnesota while promoting cooperative efforts between tribal and non-tribal agencies. In order to address concerns about this important resource, the 1854 Authority developed a *Wild Rice Action Plan*. The purpose of the plan was to outline efforts of the 1854 Authority in wild rice management, protection, and restoration.

In 1998, the 1854 Authority initiated a wild rice monitoring program on ten lakes/rivers within the Ceded Territory. (See Figure 1.) When compared to the historic record, a decline in wild rice abundance seems apparent. However, no formal record exists and present trends are less apparent. The 1854 Authority's monitoring program will document wild rice abundance, determine trends, and locate suitable sites for reseeding efforts.

In addition to the monitoring program, the 1854 Authority also conducted a wild rice survey from 1996 through 1998. The purpose of the survey was to determine the presence/absence of wild rice and to collect general information on historic rice waters. The process was coordinated with numerous partners including the Bois Forte, Grand Portage, and Fond du Lac Reservations. Fifty-two lakes/rivers within the Ceded Territory were surveyed during this period, with 10 surveyed in 1998. Information has been entered into a database and will be expanded upon in future years.

## METHODS

Wild rice monitoring occurred on the following 10 lakes/rivers in the following counties within the Ceded Territory in 1998 (see Figure 1):

- Cook County (Marsh Lake);
- Lake County (Cabin, Campers, Cramer, and Round Island Lakes); and
- St Louis County (Big Rice, Breda, Stone [a], and Stone [b] Lakes and the Vermilion River[1]).

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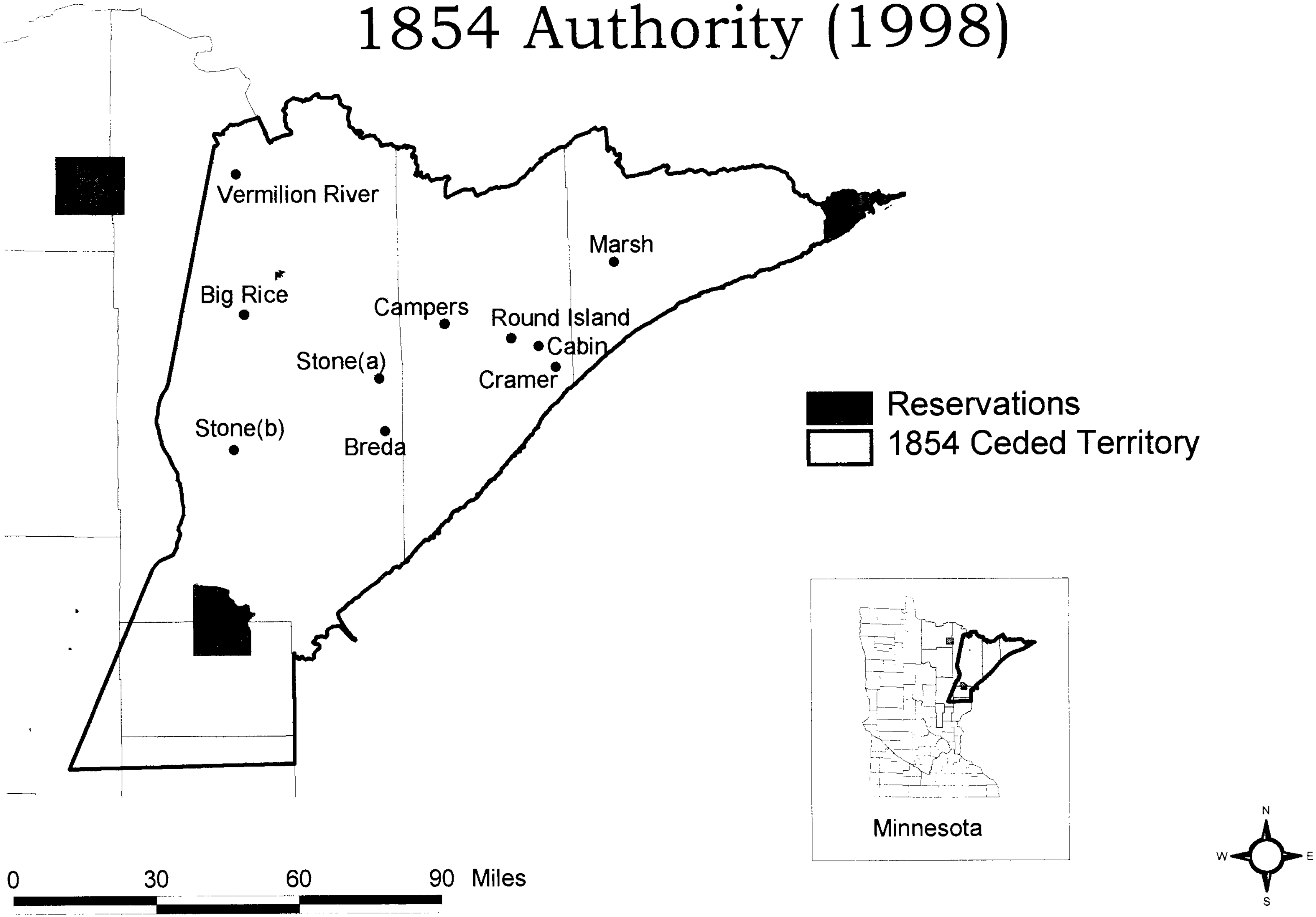
[1]The data recorded for the Vermilion River was incomplete. This report will focus on the nine lakes for which complete information was obtained.

# Wild Rice Monitoring in Minnesota
# 1854 Authority (1998)




Biological Services Division (10/98)

Lakes were chosen from information gathered from past wild rice surveys. The waters constitute a representative cross section of those surveyed (varying in size, geographic location, and amount of wild rice present in the year surveyed) and are accessible for continued monitoring. Monitoring was conducted in a consistent manner so that acquired information will be comparable between waters and across years.

**Water Depths**

Water depths were measured throughout the summer beginning as soon as possible after ice-out. A 1.52-meter section of PVC pipe was marked in 2.54-cm increments and embedded in each lake bottom to act as a depth gauge. Changes in water depth were measured by recording gauge readings throughout the summer. (Please note that this method measures *change in water depth* and makes it difficult to compare depths across years.)

**Water Temperature**

Water temperatures were recorded in conjunction with depth readings. Temperatures were taken near the water surface. In addition, temperature loggers (HOBO Temp, manufactured by Onset Computer Corporation) were used to periodically record water temperatures in each lake throughout the summer. Loggers were submerged in the spring and programmed to record temperature every 2 hours for 150 days.

**Water Quality**

Limited water quality measurements were taken periodically on each lake. Information gathered included pH, dissolved oxygen, conductivity, and total dissolved solids. Measurements were taken near the water surface. The pH was recorded using an Accumet Portable AP5 pH meter manufactured by Fisher Scientific. Dissolved oxygen was measured using a YSI Model 52 dissolved oxygen meter with a YSI Model 5718 probe. Water conductivity and total dissolved solids were measured with a Fisher Scientific digital conductivity meter. All instruments were calibrated and used according to manufacturer instructions.

**Density/Area**

Surveys to estimate wild rice density and crop size were conducted in early August when the rice was standing and reaching maturity. Wild rice density was determined from sample plots with an area of .5 $m^2$ each. A square constructed from PVC piping (~.71 m on a side) was used as a sampling grid. One corner of the grid was marked. The grid was placed over a portion of the rice bed and the number of rice stalks within it was counted and recorded. The plant nearest the marked corner was measured further. Its height above the water was first recorded. The plant was then pulled and the distance from the top of the root to the water level was measured and the number of tillers was counted. Wild rice plants were not pulled in areas with sparse numbers. Density samples were completed a minimum of 20 times per lake or until a confident average of stalks per sample could be determined. Wild rice area on a lake was determined by first drawing rice beds on the lake map. A transparent grid was overlaid to determine percent of lake covered. Given the known area of the lake, the estimated area of wild rice coverage was then calculated.

**Abundance Index**

An abundance index was developed for each lake monitored. This index was determined from the area and density of wild rice. Each lake was assigned the following density factor ranging from 1 to 5 (1=sparse, 5=dense) based on the average stalks per sample found during the survey:

| Average # Stalks per ½ sq. meter | Assigned Density Factor |
|---|---|
| 81+ | 5 |
| 61-80 | 4 |
| 41-60 | 3 |
| 21-40 | 2 |
| 0-20 | 1 |

## RESULTS AND DISCUSSION

Density survey results (see Table 1) indicated a wide range of average number of stalks per sample across the lakes. Wild rice stands were found to be most dense on Stone Lake (a), with an average of 96 stalks per sample plot, and least dense on Cabin Lake, with an average of 34 stalks. The average plant height above the water, water depth, and number of tillers also varied across lakes. One result of interest was that the average water depth on Round Island Lake was only 15.24 cm.

Wild rice area and abundance index (see Table 2) for lakes surveyed varied considerably. (The abundance index was calculated for each lake by multiplying the area of wild rice by the assigned density factor.) Abundance index will be most useful in comparing wild rice productivity across years for a given lake. Individual values will be less useful in making comparisons between lakes due to the influence of area and density. The total abundance index will be helpful in evaluating the relative success of the regional wild rice crop on an annual basis.

Breda, Campers, and Stone (a) Lakes all had excellent wild rice crops existing across the entire lake. These lakes were harvested to some extent. Round Island Lake had a good wild rice crop over nearly the entire lake. However, as mentioned above, the water level was extremely low at harvest time and throughout the summer. Access with a canoe was difficult to impossible, making harvest impractical. Cramer and Marsh Lakes also contained good rice abundance. The abundance index on Big Rice Lake was relatively high when compared to other lakes. However, the wild rice was fairly sparse across a large portion of the lake. Anecdotal evidence indicates a low abundance for 1998 with wild rice harvest down considerably. A severe storm on August 16 may have accounted for this decline. Wild rice existed across Cabin Lake, but was sparse. Stone Lake (b) did not contain a large amount of wild rice. Although good wild rice stands were located near the inlet and outlet, the majority of the lake consisted of deeper open water.

It is difficult to rate the relative 1998 success of wild rice on each lake monitored or determine factors affecting abundance because comparable data from past years is not available. A variety of interacting factors (water level and temperature, water quality, sediment nutrients, water flow, etc.) probably affect wild rice production. Besides the water temperature, change in water depth, and water quality information gathered for each lake, some other information should also be noted. The winter of 1997-98 was one of the warmest on record (due to El Niño) and an early spring occurred with little snow melt. The summer of 1998 was relatively warm and dry. Possible effects on 1998 wild rice production are unknown at this time.

## SUMMARY

The 1854 Authority initiated a wild rice monitoring program in 1998. The purpose of the program is to preserve, protect, and enhance wild rice by documenting abundance and determining trends and possible causes of increased/decreased wild rice production. Nine lakes in northeastern Minnesota were studied in 1998. Breda, Campers, and Stone (a) Lakes appeared to contain excellent wild rice crops; Cramer, Marsh, and Round Island Lakes contained good wild rice crops; and Big Rice, Cabin, and Stone (b) Lakes contained fair to poor wild rice crops. The results reveal little about the success/failure of wild rice or possible reasons controlling abundance on particular lakes. Data from subsequent years will be used to compare wild abundance and determine possible causes. The same waters will be monitored again in 1999 to obtain comparable information. The 1854 Authority plans to continue this survey on a yearly basis and hopes to expand upon the number of lakes/rivers included.

**Table 1. Wild rice density and sample plant averages (1998).**

| | | Average Numbers for Sample Plants | | |
|---|---|---|---|---|
| **Lake/River** | **Average # Stalks per ½ sq. meter** | **Height (cm)** | **Water Depth (cm)** | **# Tillers** |
| Big Rice Lake | 56 | 64 | 69 | 0.5 |
| Breda Lake | 89 | 76 | 43 | 0.9 |
| Cabin Lake | 34 | 53 | 53 | 1.2 |
| Campers Lake | 89 | 56 | 38 | 0.4 |
| Cramer Lake | 58 | 58 | 71 | 1.0 |
| Marsh Lake | 76 | 43 | 48 | 1.8 |
| Round Island Lake | 82 | 48 | 15 | 0.5 |
| Stone Lake (a) | 96 | 76 | 58 | 1.5 |
| Stone Lake (b) | 66 | 58 | 48 | 1.6 |

**Table 2. Wild rice area and abundance index (1998).**

| | | 1998 | | |
|---|---|---|---|---|
| **Lake/River** | **Lake Area (hectares)** | **Rice Area (hectares)** | **Density Factor** | **Abundance Index** |
| Big Rice Lake | 757 | 575 | 3 | 1725 |
| Breda Lake | 55 | 51 | 5 | 255 |
| Cabin Lake | 27 | 27 | 2 | 54 |
| Campers Lake | 23 | 23 | 5 | 115 |
| Cramer Lake | 25 | 22 | 3 | 66 |
| Marsh Lake | 28 | 21 | 4 | 84 |
| Round Island Lake | 22 | 20 | 5 | 100 |
| Stone Lake (a) | 93 | 70 | 5 | 350 |
| Stone Lake (b) | 55 | 7 | 4 | 28 |
| ***Totals:*** | | **816** | | **2777** |

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# AN OVERVIEW OF THE GREAT LAKES INDIAN FISH AND WILDLIFE COMMISSION'S WILD RICE MANAGEMENT PROGRAM

Peter David


## ABSTRACT

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) conducts a multifaceted wild rice management program in the ceded territories of the Upper Great Lakes region. This paper provides an overview of the program by addressing the five main program components. The first component is annual abundance monitoring. The paper will review abundance trends from 40 Wisconsin waters that have been surveyed since 1985 and summarize trends in annual abundance on a state and regional level and for selected individual waters. The second component is Wisconsin off-reservation harvest estimation, which has been conducted since 1987 for state and tribal ricers. Year-to-year differences in harvest estimates will be compared to abundance estimates, and state and tribal harvest estimates will be contrasted. The third component is restoration and enhancement of historic and non-historic wild rice beds. The Great Lakes Indian Fish and Wildlife Commission coordinates a highly cooperative wild rice restoration and enhancement program, with numerous tribal, state, federal, and local organizations, in which 2.7 to 6.3 metric tons of rice is seeded annually. Restoration and enhancement guidelines will be presented in the paper, and the successes and challenges of this effort will be reviewed. The fourth component is public information/education. The paper will highlight GLIFWC's efforts to provide the public with informational brochures and lake postings about wild rice habitat. The fifth component is research. The paper will review several recent and current small-scale wild rice research projects.


## INTRODUCTION

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is a natural resource agency whose mission is to assist its 11 member tribes (the Bad River, Lac Courte Oreilles, Lac du Flambeau, Red Cliff, St Croix, and Sokaogon tribes in Wisconsin; the Bay Mills, Keweenaw Bay, and Lac Vieux Desert tribes in Michigan; and the Fond du Lac and Mille Lacs tribes in Minnesota) in the exercise of their off-reservation treaty-reserved rights. The geographic area that GLIFWC works in includes lands ceded in the treaties of 1836, 1837, 1842, and 1854 and includes areas that later became parts of Wisconsin, Minnesota, and Michigan. The organization has a particularly intense interest in *manoomin* (wild rice) because of the great cultural significance this plant has to the Anishinaabe people. This has led to the development of a multi-faceted wild rice management program that addresses the main program components outlined in the sections that follow.

## ANNUAL ABUNDANCE MONITORING

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is interested in monitoring wild rice abundance because, although it is known that wild rice is less abundant than it was historically, it is unclear whether wild rice is continuing to decline or has now stabilized at a lower abundance level.

This is not a question that can easily be answered in the short-term because of the great natural variability in abundance that wild rice can exhibit from year to year. This variation can be quite dramatic. For example, Totogatic Lake in Bayfield County, Wisconsin, supported 166 hectares of wild rice in 1995, but only 6 hectares the following year. A stand of 178 hectares in 1997 indicated that the decline was not indicative of a permanent decline. Only long-term abundance monitoring will be able to strip away this natural variation and allow true trends in abundance to be discerned.

With this in mind, GLIFWC selected a group of 40 Wisconsin wild rice waters varying in size and amount of water flow and began surveying their abundance each year, beginning in 1985. These surveys are usually conducted by summer interns who field-check each site, mapping the size of the beds and measuring their density.

Because of the relatively large number of waters surveyed, most of the mapping is done on a fairly crude, "eye-ball estimate" basis. This can be difficult to do, especially on larger water bodies. In addition, the use of summer interns (rather than permanent staff members) introduces a concern about year-to-year variation in data collection arising from changes in observers.

Thus, as a second component of the annual surveys, GLIFWC permanent staff members also conduct an aerial survey of various wild rice waters, including many of the waters surveyed by the ground crew. The air surveys allow many waters to be surveyed quickly and relatively inexpensively and provide the best estimates of wild rice area on larger water bodies. On the negative side, only crude estimates of bed density are possible, and sparse beds, especially where intermixed with other vegetation, can be missed altogether. Aerial survey results are also more likely to be influenced by lighting and observer comfort. Ground surveys allow detailed density information to be collected, and they are sensitive to small and sparse stands, but they are time-consuming and may give poorer estimates of area on larger sites. However, by combining these survey techniques, we believe we are gaining solid information on annual abundance trends in the Wisconsin Ceded Territory.

The data collected from the 40 waters is summarized into an annual abundance index. This is done by multiplying the area of the beds by a stand density factor, a value of 1 through 5, representing sparse to dense. We then sum the values derived for all 40 waters surveyed.

We are now entering the fifteenth year of data collection on these waters, and we are beginning to get enough trend information to be interesting. One of our findings is that the inclusion of stand density data tends to smooth out some of the year-to-year variation that is observed when only area data is used. (See Figure 1.) It is also interesting to note that when wild rice is looked at on this broad, multi-water level, there is some indication that it may be cycling on a rather large time scale. This is much different than the rule of thumb that many harvesters apply to individual lakes, of a typical four-year period containing a boom and a bust year and two middling years.

If the over-all abundance index is split into north-central and northwestern waters, another interesting pattern emerges. (See Figure 2.) For the period from 1985 through 1991, rice abundance in these two areas trended together in remarkable unison. Since 1991, however, these areas have frequently displayed different directions in annual abundance. It is difficult to find a simple explanation for these results, but they suggest that wild rice can be strongly affected by different variables that act at different scales.

## WISCONSIN OFF-RESERVATION HARVEST ESTIMATION

The second component of our wild rice management program consists of conducting annual harvest surveys of state and tribal ricers. We are interested in harvest for several reasons. First, it gives us a sense of how much harvesting pressure is on the resource. Harvest data can also provide some insight into the effectiveness of our seeding program (described below), and, finally, it can provide a secondary index to wild rice abundance that is unconnected to our abundance surveys. Harvest estimates have been made annually since 1987, with the exception of 1988. The Wisconsin Department of Natural Resources (WDNR) cooperates in this survey by providing the names and addresses of individuals purchasing state ricing licenses.

Because of differences in licensing procedures and activity rates, the harvest estimates for state and tribal ricers actually come from two separate

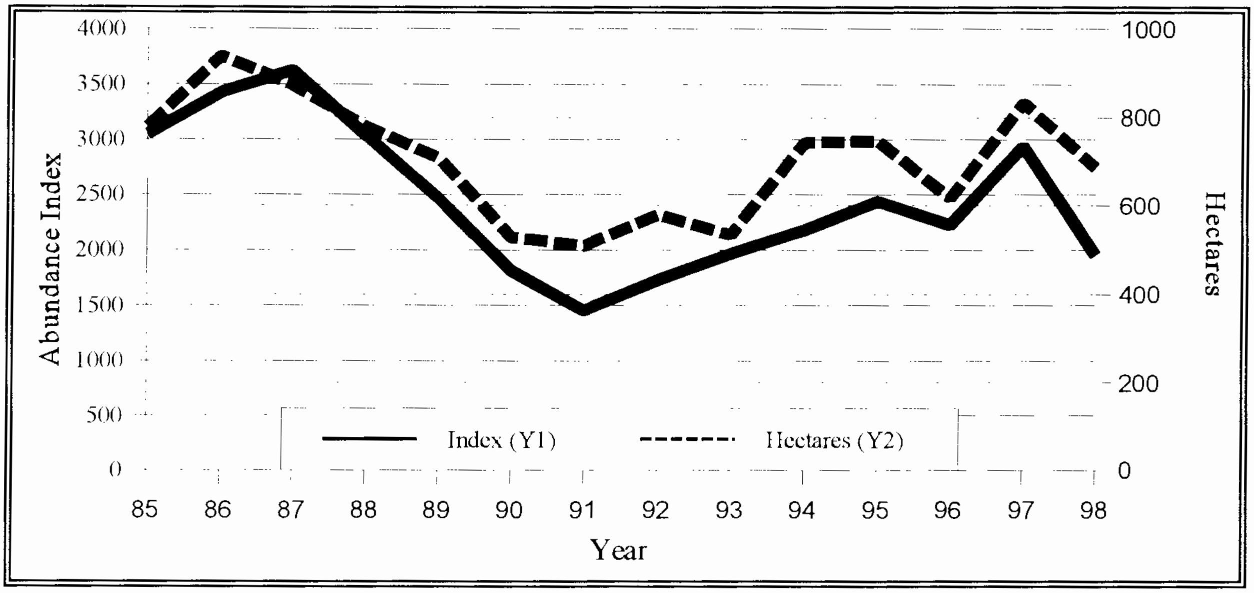


**Figure 1. Wild rice hectares and abundance index from 40 Wisconsin waters surveyed annually from 1985 through 1998.**

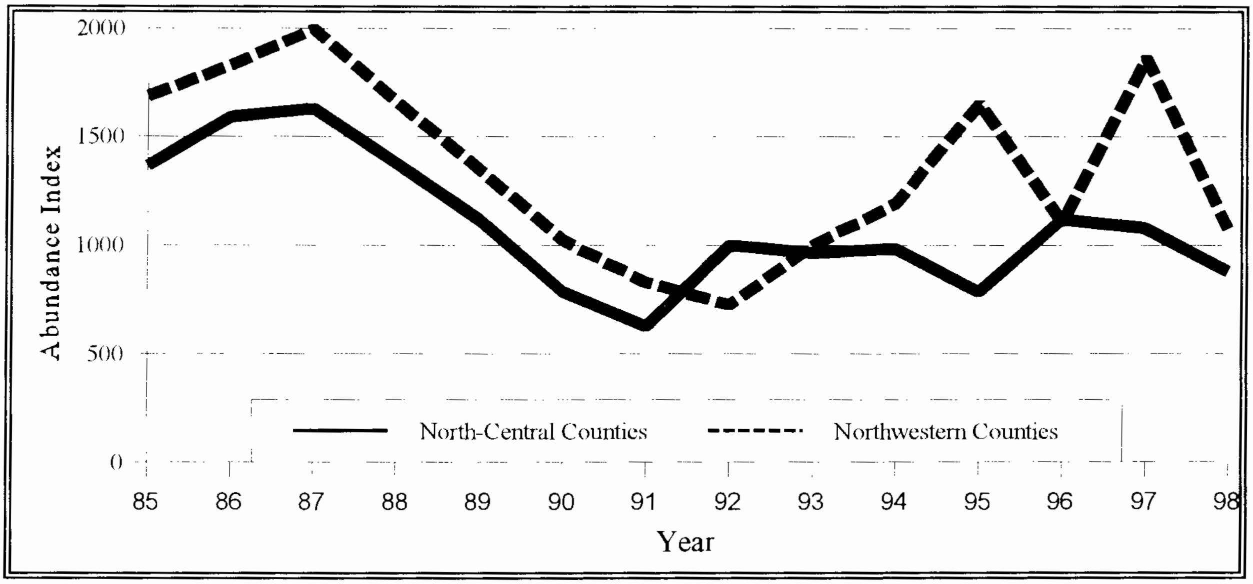


**Figure 2. Wild rice abundance index from 40 northwestern and north-central Wisconsin waters surveyed annually from 1985 through 1998. Highway 13 is used to separate northwestern from north-central waters.**

surveys. State ricers, who must purchase a licence, typically have activity rates over 90% and are surveyed by mail. Tribal permittees have much lower activity rates (generally in the vicinity of 20%) because the tribal permit is a check-off category on a free natural resources gathering permit that includes several other activities. As a result, tribal permittees are separated into active and inactive groups based upon the previous year's activity. Both groups are then surveyed (with an emphasis on the active group) by phone in an effort to reduce the response bias that can occur with mail surveys of groups with low activity rates.

Separate harvest estimates are then made for each group. However, these estimates also differ in one important way. The state survey produces an estimate of total harvest by state licensees, while the tribal harvest estimate is only for off-reservation harvest, because the tribes generally do not require their members to have a permit to harvest on-reservation. By combining these surveys, however, we can gain good estimates of total off-reservation harvest in the state.

Estimates for total off-reservation harvest in Wisconsin since 1987 have varied more than five-fold, from 9525 kg in 1991 to 51,256 kg in 1997. (See Figure 3.) Over this period, 39% of the off-reservation harvest has come from tribal members. As 1997, the year of highest harvest illustrates, tribal members make more ricing trips per year and harvest more rice per license than state licensees. (See Table 1.) This is probably due to the greater tradition of ricing among tribal members and the smaller percentage of first-time ricers in their ranks.

The distribution of harvest roughly reflects the distribution of wild rice waters in the state and the abundance of rice on those waters. From 1994 through 1998, nearly 180,000 kg of rice was harvested from off-reservation waters by state or tribal ricers. Although nine different counties accounted for 2% or more of the total harvest, just three counties (Burnett, Vilas, and Bayfield) produced nearly two-thirds of the total. (See Table 2.) The distribution of harvest was roughly similar for state and tribal ricers with the exception that Bayfield County was more important to tribal members, and Burnett County was more important to state ricers. Only small amounts of rice have been reported harvested from outside the Wisconsin Ceded Territory by state licensees.

The abundance surveys have proven to be remarkably attuned to the independent harvest estimates. Over the past 10 years, the correlation between the abundance index and the harvest estimate has produced an $r^2$ value of 0.88. Thus, it appears that despite the rather crude scale of area estimation, enough waters are surveyed to produce an excellent index to over-all abundance. (Each year's abundance and harvest information is summarized in an annual report available from GLIFWC.)

## RESTORATION AND ENHANCEMENT OF HISTORIC AND NON-HISTORIC WILD RICE BEDS

Perhaps the most rewarding aspect of GLIFWC's *manoomin* management program is the seeding effort. Seeding is important because of the decline in wild rice abundance from historic levels and because of the fairly limited dispersal of the seed under natural conditions. Seeding is attempted both in efforts to restore historic rice beds and to establish rice in sites such as artificial flowages, which have suitable habitat but previously have not supported rice. Since restoration is not possible on many of the historic waters (due to changes in habitat and water levels), these latter locations provide an important opportunity to restore some of the historic abundance of rice on a landscape level.

The seeding program is truly a cooperative effort. The increased tribal presence in the natural resource management arena has markedly increased people's awareness of wild rice, and more and more organizations are interested in rice enhancement projects. Over the last decade, GLIFWC has joined efforts with the Wisconsin and Michigan Departments of Natural Resources, the U. S. Fish and Wildlife Service, the Chequamegon/Nicolet and

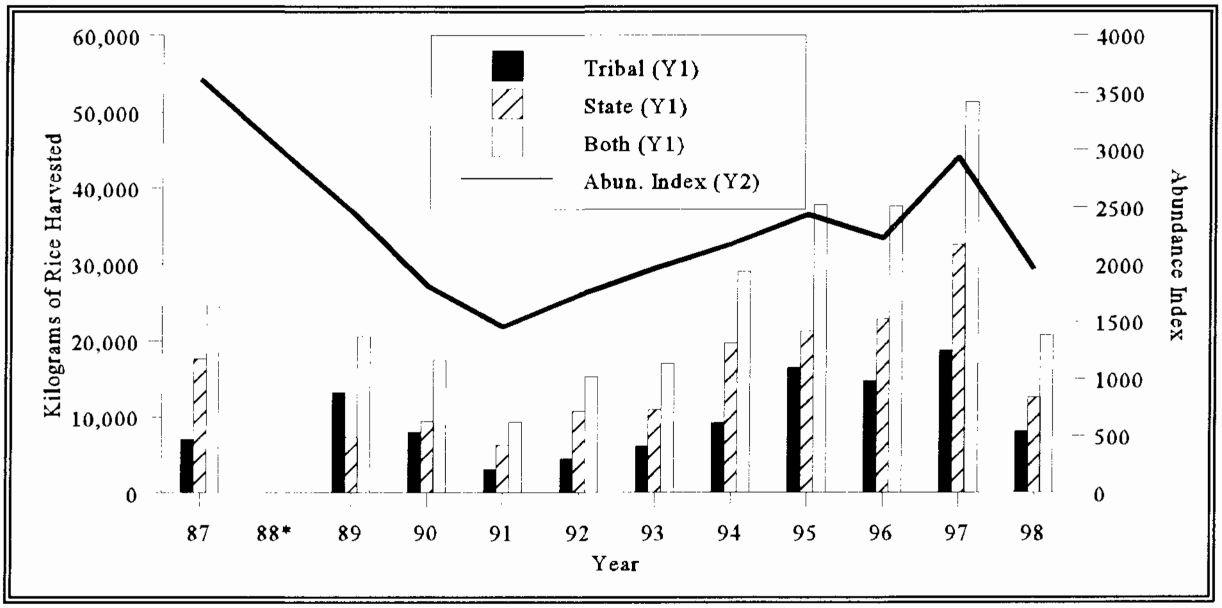


**Figure 3. Harvest trends versus abundance index, 1987 through 1998. *There is no harvest estimate available for 1988.**

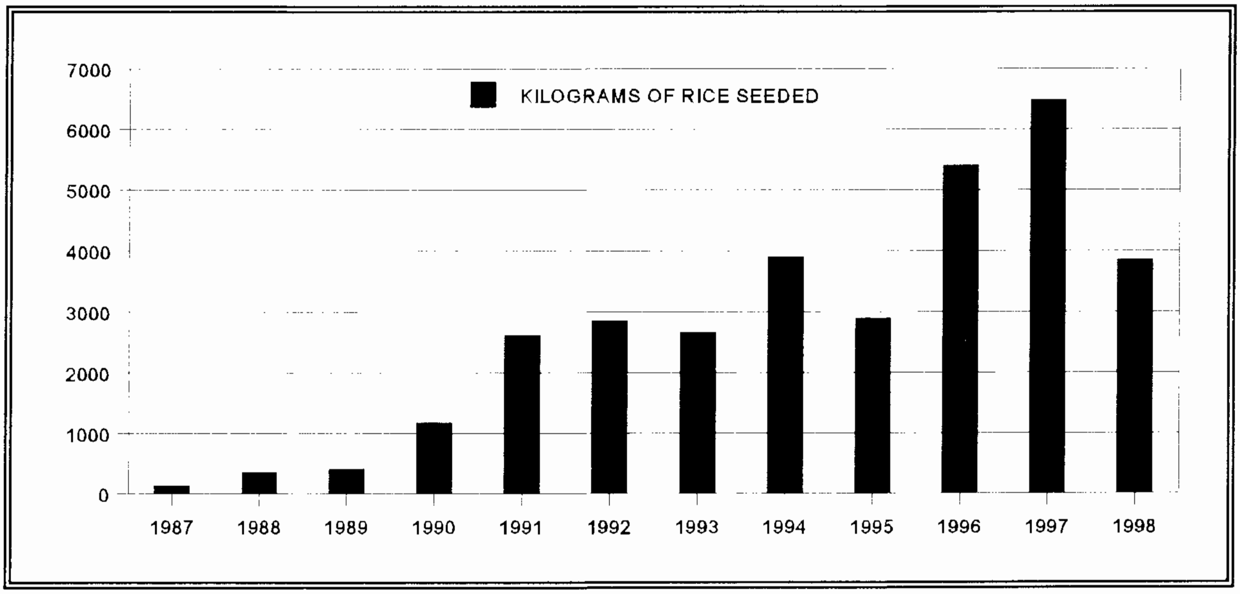


**Figure 4. Kilograms of rice seeded in GLIFWC/cooperator projects, 1987 through 1998.**

| Table 1. A comparison of 1997 tribal and state off-reservation wild rice harvests. All weights are kg. | | | | | | |
|---|---|---|---|---|---|---|
| | NUMBER OF PERMIT HOLDERS | ESTIMATED NUMBER ACTIVE | AVERAGE NUMBER OF TRIPS | AVERAGE HARVEST/ TRIP | AVG. HARVEST /ACTIVE LICENSE | TOTAL ESTIMATED HARVEST/TRIPS |
| TRIBAL | 922 | 176 | 3.4 | 32 | 107 | 18,748/592 |
| STATE | 508 | 465 | 2.7 | 26 | 70 | 32,542/1246 |
| TOTAL | 1430 | 641 | 2.9 | 28 | 80 | 51,290/1838 |

| Table 2. Counties accounting for more than 2% of the total Wisconsin off-reservation wild rice harvest, 1994 through 1999. | | | |
|---|---|---|---|
| COUNTY | PERCENT OF TRIBAL HARVEST | PERCENT OF STATE HARVEST | PERCENT OF TOTAL HARVEST |
| Burnett | 31.2 | 38.4 | 35.7 |
| Bayfield | 19.8 | 10.4 | 14.0 |
| Vilas | 16.7 | 12.7 | 14.3 |
| Sawyer | 7.0 | 8.2 | 7.7 |
| Douglas | 10.3 | 6.0 | 7.7 |
| Oneida | 5.7 | 8.5 | 7.4 |
| Washburn | 5.1 | 1.8 | 3.1 |
| Price | 0.8 | 4.0 | 2.8 |
| Taylor | 0.0 | 4.2 | 2.6 |

Ottawa National Forests, Ducks Unlimited, the Wisconsin Waterfowl Association, our member tribes, and even private organizations and volunteers. Over this time, the effort has grown significantly, from a program that started measuring rice by the kilogram, and now does so by the metric ton. (See Figure 4.) This was made possible in large part thanks to the U. S. Bureau of Indian Affairs and the Circle of Flight program, which have funded much of GLIFWC's side of these cooperative efforts.

Our seeding program is decidedly "low-tech." Potential seeding sites are visited to evaluate their rice potential by examining water clarity, bottom types, existing competition, and other factors. If a historic bed is involved, an effort is made to determine what factors may have lead to the loss of the original stand.

If the site seems to provide suitable habitat, we begin with a test seeding. The actual seeding process is simply a matter of obtaining and broadcasting seed. In most instances, seed is purchased from hand harvesters and is hand broadcast in the fall. Some general seeding guidelines have been developed:

- begin with a test seeding of roughly 1.3 hectares;
- seed at a rate of 45 to 55 kg per hectare;
- plant seed in the fall;
- plant seed as soon after its harvest as possible;
- monitor the site several times during the following growing season, if possible;
- expect to seed each site for 3 to 5 years; and
- expand seeding as results are observed.

Although many of these cooperative seeding efforts are still underway, and some sites have not produced the hoped-for results, it is clear that success is often possible. Harvest surveys in recent years have indicated that nearly 10% of the harvest is coming from restored or introduced sites, an indication that this program is making a noticeable contribution towards restoring some of the lost abundance of rice on the landscape. This is particularly encouraging because significant human harvest is not anticipated at all seeding locations; thus, the actual increase of rice on the landscape may be even higher than the 10% increase harvest figures suggest.

Some of the success stories of this cooperative effort include the Phantom Flowage at the Crex Meadows Wildlife Area in Burnett County, Wisconsin (WDNR cooperator); several impoundments on the Pershing Wildlife Area in Taylor County, Wisconsin (WDNR cooperator); Crooked Lake in the Sylvania Wilderness Area in Gogebic County, Michigan (Ottawa National Forest cooperator); Wilson Flowage in Price County, Wisconsin; and Rat River in Forest County, Wisconsin (Chequamegon/Nicolet National Forest cooperator). These and a host of other sites reflect the potential of seeding efforts and encourage us to carry these efforts into the future.

## PUBLIC INFORMATION/EDUCATION

In recent years, we have grown more active in the fourth component of our rice management program: public information/education. This effort has taken the following forms.

### Ecology/Harvest/Management Brochure

This full-color brochure was created and printed with the assistance of the Wisconsin and Minnesota Departments of Natural Resources, U. S. Fish and Wildlife Service, and Bureau of Indian Affairs. It provides an overview of the ecology, harvest, and management of wild rice, as well as describing its ecological and cultural significance. It is distributed free of charge at various state, federal, and tribal outlets. Demand for it has been significant.

### Boat Landing Signs

The increase in boating pressure on many wild rice waters has produced a need for informational signs at public boat landings. Spring boaters are often unaware of the presence of rice on the waters they frequent. Although boaters generally stay out of rice beds once the plants have emerged, they can have serious impacts when they unknowingly run though beds while the plants are still below the surface.

In response to this need, an informational sign was developed to alert boaters to the presence of rice beds on certain lakes and asks them to use care when boating near the beds. The sign also provides GLIFWC and WDNR addresses where the reader can obtain additional information. This sign has been posted at selected wild rice waters across the Wisconsin Ceded Territory in cooperation with the WDNR and the U. S. Forest Service.

### GLIFWC Web Page

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) posts harvest regulations, lake opening and abundance information, aerial photos of wild rice beds, and an electronic form of the Ecology/Harvest/Management brochure on its web page. The information is updated annually or as necessary.

All of these public outreach efforts have a common goal: to increase the public's interest in and awareness of this unique resource. The need for this is great; shoreline development is increasing on many wild rice waters; there are many new landowners; and boating pressure is greatly increasing. In the course of our survey work, it is not unusual for us to run into property owners who are unaware that the plant that is growing off the edge of their docks is *manoomin*. Our experience has been that the more information people have about this resource, the more likely they are to view it from a stewardship perspective, rather than simply considering it a nuisance that wraps around their boat propeller. By increasing the size of the public "wild rice constituency," we will expand the number of people who are watchful and protective of this rare resource.

**RESEARCH**

The final primary component of GLIFWC's management program consists of *manoomin* research. Although GLIFWC has not had the opportunity to conduct a large amount of rice research to date, we are becoming more active in this arena, and our efforts will likely expand as additional funding becomes available.

Some of GLIFWC's cooperative research activities are presented separately in this volume. James Bennett's paper titled *Heavy Metals for Wild Rice from North Central Wisconsin* provides important baseline data on the levels of various heavy metals in local populations of wild rice as well as information on how those metals are distributed in the plants. This can have important implications for human consumption as well as for the plant itself.

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is also keenly interested in wild rice genetics and supported Don Waller's research for his paper titled *Genetic Variation among Populations of Wild Rice (Zizania aquatica) in Northern Wisconsin*. The Commission's interest in genetic variability is motivated in part by our seeding program, which has had to proceed thus far without an understanding of this important component of the plant's biology. This type of work could make *manoomin* the first wild plant in the ceded territories for which management decisions are influenced in part by genetic considerations. This work will be expanded in scope in the year ahead thanks to support from the U. S. Forest Service.

There was a second component to the initial phase of the genetics study that examined the phenotypic variation of rice at the sites sampled for genetic variation. Plants were collected from each of the sites and measured for a number of different variables such as plant height, leaf width, and dry weight.

We found that for some basic variables, such as plant height and number of seeds produced per head (see Figure 5), there was no overlap between plants collected from the northwest and north-central portions of the state. Other factors, such as seed size, however, did not show this trend. A crude comparison of seed size and the amount of water flow at each site suggests that seed size might be negatively correlated with water flow.

The Commission is also exploring other possible plant-habitat relationships. With the assistance of U. S. Forest Service funding, we are beginning to take a look at the relationship between sediment density and water turbidity and to see how boat traffic might affect turbidity in the soft-bottomed lakes that frequently support wild rice. All of these research directions help piece together our knowledge of wild rice biology. Hopefully, they will assist us in our efforts to protect and enhance this unique resource for the Seventh Generation.

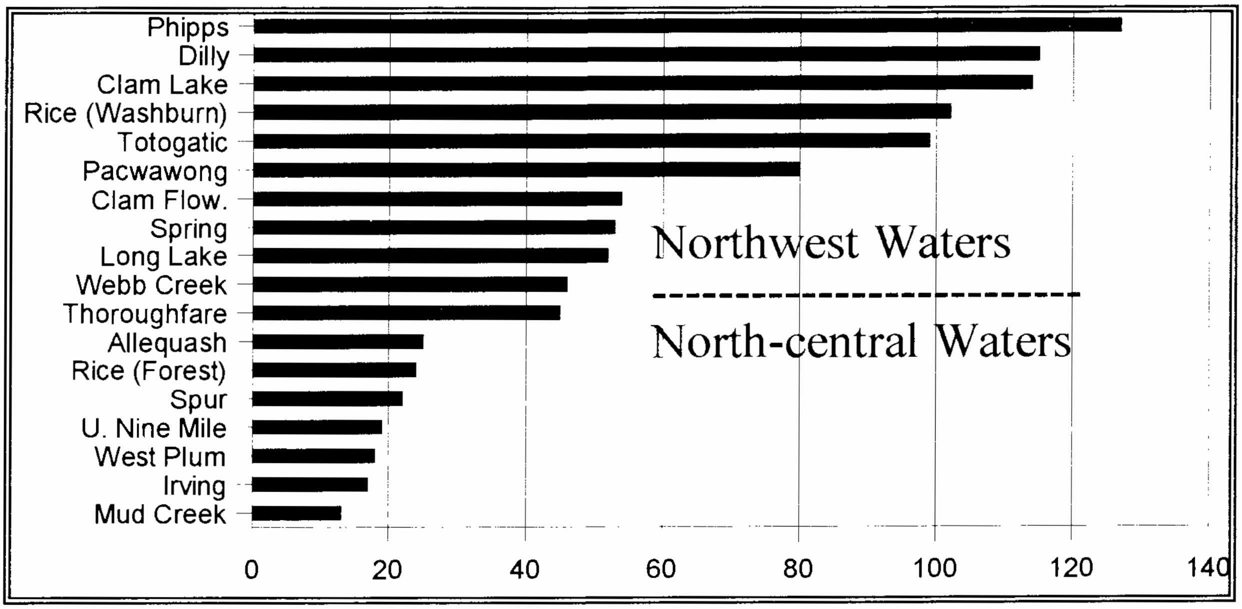


**Figure 5. Average number of seeds per head, northwest versus north-central Wisconsin waters.**

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# RICE PORTAGE WILD RICE AND WETLAND RESTORATION PROJECT

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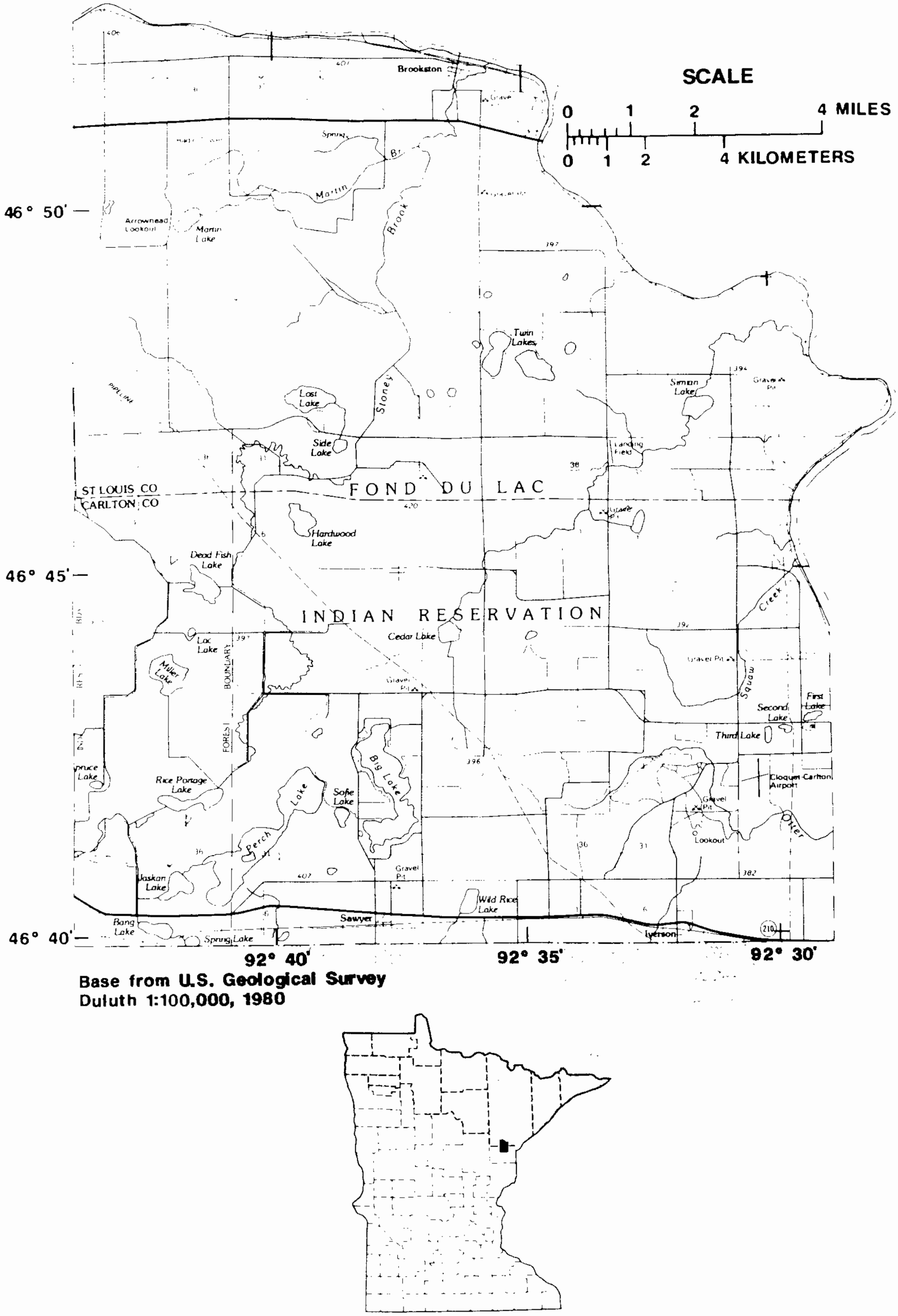
## ABSTRACT

Many of the wild rice lakes on the Fond du Lac Reservation were severely impacted by a drainage ditch system that was dug from 1916 to 1921. The ditches lowered the water levels of five wild rice lakes and altered the hydrological characteristics of the streams and lakes of the Stoney Brook watershed. The Fond du Lac Natural Resources Program conducted several years of planning, surveys, and hydrological data collection in order to design a system of four water control structures and an impoundment to restore the lakes to their original elevations and hydrological functions. The most ambitious part of this project is to restore Rice Portage Lake to its original size of 257 hectares. This lake currently has only 46 hectares of open water in which wild rice grows. The new outlet dam will be used to control water levels to restore the lake to its original elevation in eight to ten years. Mechanical conversion of the encroached competing vegetation to open water wild rice habitat will be used to restore the wild rice stands on the lake. A 29-hectare impoundment has also been created upstream of Deadfish Lake to prevent the flooding of this lake and the destruction of the wild rice stands on it. The system of wild rice lakes and the solution to the problems that the ditch system imposed on the lakes is described. Traditional and current scientific knowledge of wild rice ecology and a hydrological model will be used to manage the lakes, as closely as possible, to a natural system of lakes and streams without the impacts of a human-made drainage system.

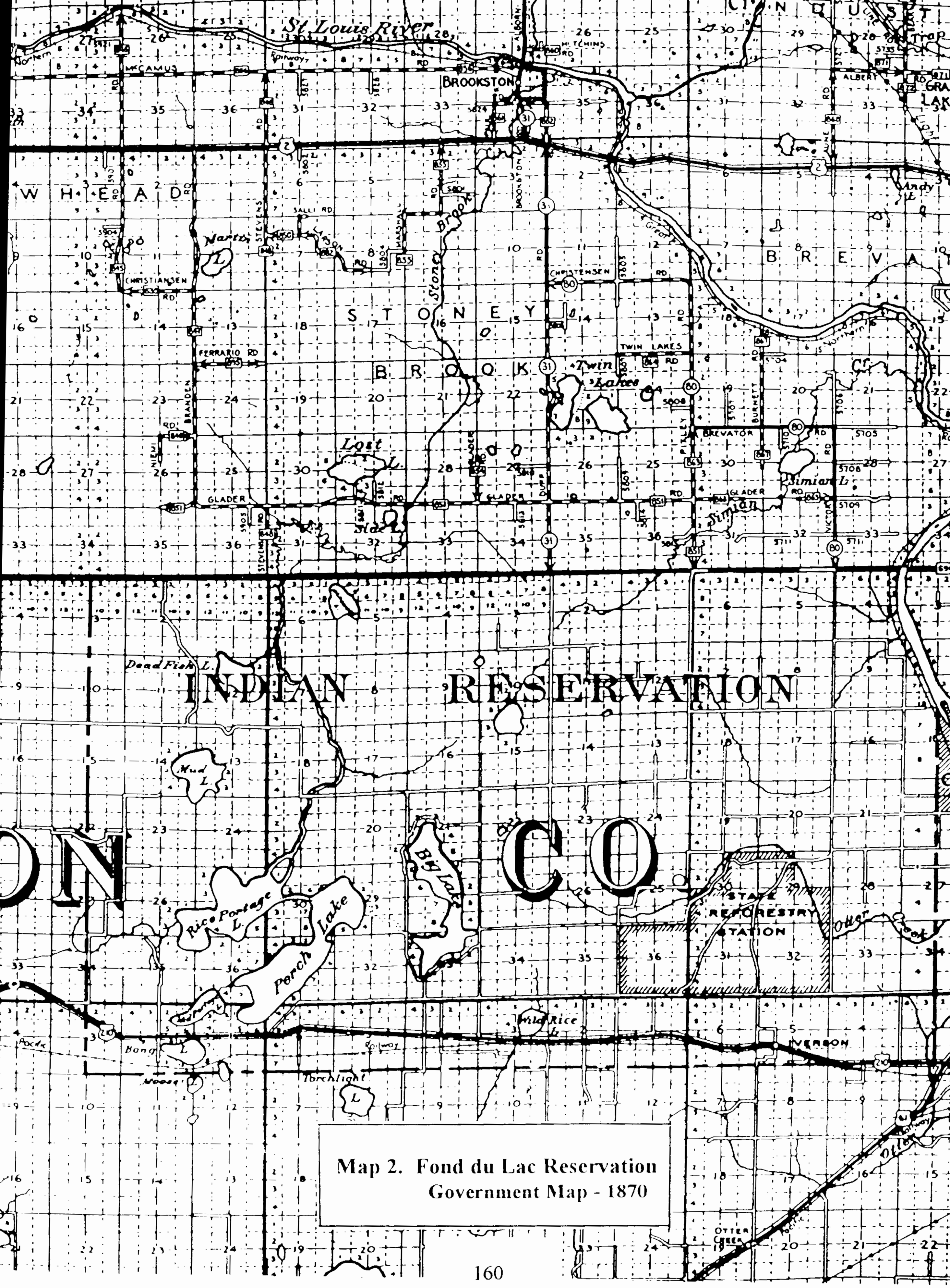
## HISTORICAL PERSPECTIVE AND STATUS OF THE WILD RICE ECOSYSTEM ON FOND DU LAC

Wild rice, or *mahnomin*, has been of great cultural and spiritual importance to the Ojibway people for hundreds of years. The Fond du Lac Band of Lake Superior Ojibway have lived near the western end of Lake Superior for centuries, and have relied on the region's wild rice stands each year. The gathering of wild rice as a staple food has been vitally important for many generations. The wild rice lakes on what is now the Fond du Lac Reservation were very important in the annual cycle of fishing, hunting, and gathering. The boundaries of the Fond du Lac Reservation were selected by the Band to encompass these important wild rice lakes and the once abundant hunting and fishing areas (see Map 1). The five primary wild rice lakes located in the southwest part of the Reservation are now known as Perch, Jaskari, Rice Portage, Mud or Miller, and Deadfish Lakes.

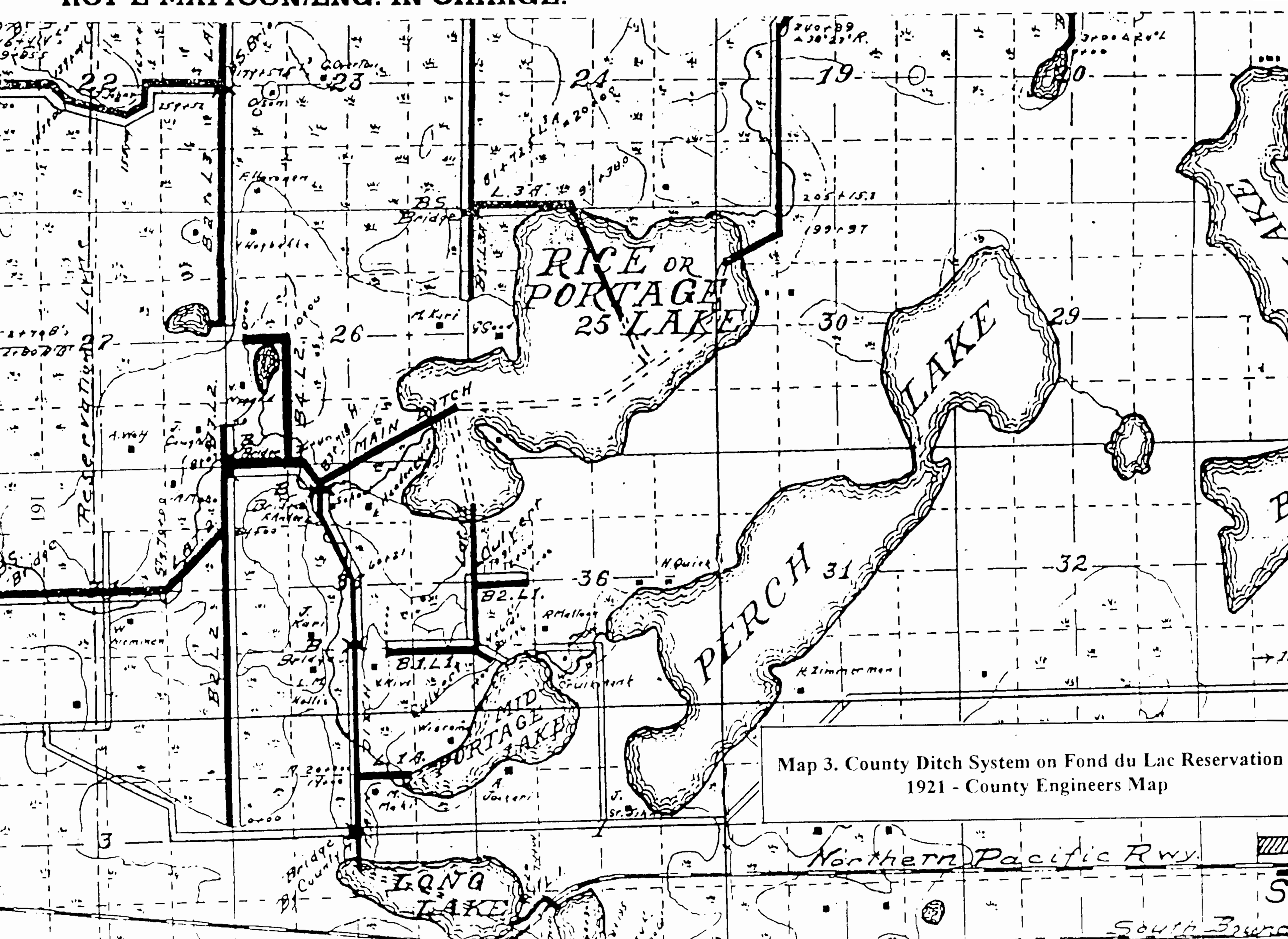
In the early 1900s, plans were developed by Carlton County to dig a ditch through the upper Stoney Brook watershed and the chain of wild rice lakes that comprise much of this waterway. The five primary wild rice lakes were adversely impacted by the drainage ditch system. Map 2 (based on the 1870 survey) shows the extent of the wild rice lake and the original stream channel prior the excavation of the ditch. The ditch system was dug with steam shovels, starting in 1916 and finishing in 1921 (see Map 3). The ditch system lowered lake levels significantly on the wild rice lakes, resulting in major impacts to the wild rice ecosystem on these lakes. Many hectares of wild rice stands were eliminated because the water depths were lowered on the lakes and competing wetland vegetation grew in its place. Rice Portage Lake was especially affected by the drainage. Its original area of 257 hectares was diminished to only 46 hectares of open water in which wild rice could grow. The ditch system also altered the natural hydrological characteristics of the upper Stoney Brook watershed, resulting in unnatural extremes of water level and flow conditions on the wild rice lakes. The




Map 1. --Location of the Fond du Lac Indian Reservation.




**Map 2. Fond du Lac Reservation Government Map - 1870**




Map 3. County Ditch System on Fond du Lac Reservation
1921 - County Engineers Map

lower lake levels also changed the relationship of these headwater lakes to the overall ditch and stream gradient, which results in a reduced discharge capacity for the ditch system. Although the ditches can increase the water volume entering a lake, the lower gradient of the upper watershed ditch system can make it more difficult for the water to discharge from a lake. This is often a problem after summer rain storms because the ditches upstream of Deadfish Lake discharge large quantities of water into the lake. However, the lower lake level then results in the inability to discharge these incoming waters at the same rate. The result is significant flooding events on Deadfish Lake, which has destroyed most of the wild rice plants at this site for the past several years. Rice Portage Lake exhibits this problem to a lesser degree because its water storage basin is considerably larger than that of Deadfish Lake.

## WILD RICE MANAGEMENT AND RESTORATION ON FOND DU LAC

The Ojibwe people have protected and managed wild rice lakes for centuries, and have been and will continue to be at the forefront of efforts to protect, study, and manage this invaluable resource throughout the region. For many generations, the Ojibwe people of Fond du Lac have understood the natural cycles of wild rice growth and the management of lakes to optimize the abundance of this unique aquatic plant. Water control measures were attempted over the years after the ditch system drained the wild rice lakes on the Fond du Lac Reservation. Control of beaver dams and ditch maintenance also was necessary over the years to prevent spring and early summer flooding of the lakes. These efforts were labor intensive and sometimes only partially successful. The protection of the wild rice lakes from development that could adversely affect them is an important part of the Fond du Lac Band's commitment to this important resource. In recent years, managers of the Fond du Lac Natural Resource Program and Environmental Program have incorporated up-to-date scientific and resource management techniques, in combination with the cultural knowledge of wild rice, to develop more effective efforts to protect and manage this resource.

### Rice Portage Wetland and Wild Rice Restoration Project

The Fond du Lac Natural Resources Program managers have worked several years on planning and implementing the Rice Portage Wetland and Wild Rice Restoration Project to construct four water control structures and a flood retention impoundment. This project will improve water management on the wild rice lakes and restore the lakes to their historical size and condition. The four water control structures on Perch Lake, Rice Portage Lake, Deadfish Lake, and the Upper Deadfish Impoundment were completed in 1999 and will provide the capability to optimize water level management for wild rice growth. The funds for constructing the dams came from the Fond du Lac Reservation, the North American Wetland Conservation Act/Council, the U. S. Natural Resources Conservation Service, the Minnesota Department of Natural Resources, Ducks Unlimited, the U. S. Fish and Wildlife Service, and corporate sponsors. The water control structures will result in significant increases in wild rice habitat and abundance on Perch Lake, Rice Portage Lake, and Deadfish Lake.

### Perch Lake

Perch lake is the headwaters of Stoney Brook watershed. It is a 266-hectare lake, of which 166 hectares is managed for wild rice. The drainage area of this lake is 10.8 square km. The dam that was built in 1936 was non-functional for many years and has been replaced with a new steel and concrete control structure. The partial drainage of the lake and lack of water control caused a decline in the wild rice and wetland community on Perch Lake. Pickerel weed (*Pondetaria cordata*), locally known as "moose ear," has displaced more than 61 hectares of wild rice. The pickerel weed is out-competing wild rice for important nutrients in the 166 hectares of the lake that is managed for wild rice. The Reservation's "cookie cutter" and aquatic weed harvester work together to cut up and remove this competing plant.

### Rice Portage Lake

Rice Portage Lake was ditched in 1921, resulting in a 46-hectare wild rice lake, with extensive encroachment of macrophytes on much of its original 257 hectares The adjacent wetland community was also degraded. The water control structure completed in 1999 is now being used to raise the lake to its historical size and to provide enough water depth to use the vegetation control equipment to convert the encroached cattail and sedge mat to wild rice habitat. The restoration of the many hectares of wild rice stands should be completed by 2004.

### Deadfish Lake

Prior to the excavation of the ditch system, Deadfish Lake was a 41-hectare wild rice lake. It drains 45 square km of the Stoney Brook watershed. The remaining 32-hectare lake can sometimes produce abundant wild rice. However, the ditch system has made water level fluctuations a severe problem. The resulting changes to the hydrological functioning of this watershed has meant that the lake is susceptible to high water, which drowns out the wild rice crop. A flood retention impoundment of approximately 29 hectares was created on the ditch upstream of Deadfish Lake, which will alleviate much of the lake's water level fluctuation.

### Other Wild Rice Lake Management and Research Activities

Other wild rice management and research activities that are part of the Fond du Lac Natural Resources Program include:

- hydrological data collection, modeling, and analysis;
- water control structure operation and maintenance;
- wild rice growth monitoring through field surveys and aerial photos;
- control and conversion of competing vegetation to wild rice habitat conditions; and
- managing the Reservation's purchasing of wild rice seed and seeding the lakes where it is necessary.

### Wild Rice Ecosystem Studies

Regular water quality and sediment nutrient sampling and analysis will be correlated with the wild rice growth data from field studies and aerial photos. The relationship of site-specific nutrient availability with wild rice growth and abundance will help us understand the ecological relationships between lake morphology, geology, water quality, nutrient cycling, and other contributing factors. This information is critical to understand the changes taking place from our management and restoration activities, to select areas requiring wild rice seeding, and to evaluate potential land management and protection efforts.

Investigation of heavy metal levels in the lake sediments will also be investigated to determine if the increases in these contaminants from anthropogenic sources may adversely affect wild rice growth and/or nutrient cycling. This is a follow-up to our studies of the depleted wild rice stands on the lower St Louis River estuary, which strongly suggested that mercury contamination is preventing normal germination.

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# WILD RICE MONITORING IN NORTHERN MANITOBA USING RADARSAT-1

R. J. Dixon
A. Derksen

## ABSTRACT

Wild rice (*Zizania* L.) has existed in southeastern Manitoba since before European settlement. It was first introduced during the early 1980s into the northwest-central region of Manitoba. Most of the lakes that were seeded are located in the Flin Flon-The Pas area. The spread of wild rice in this region has been aided by the construction of forest harvesting roads. Ten years after the first introduction of wild rice, a number of issues have been raised by other resource users. Fisheries managers have become concerned with the possible impacts on fish habitat. Wild rice is typically seeded in shallower bays and along the inshore waters of lakes. These littoral areas are generally very productive for young-of-the-year fish.

LANDSAT imagery has been used in the past to monitor wild rice habitat in the Flin Flon-The Pas area. The difficulty with LANDSAT is resolution and timeliness of data aquisition. This paper reviews the role of RADARSAT-1 in mapping and monitoring the areal extent of wild rice in the boreal forest regions of northern Manitoba. The all-weather capability of RADARSAT-1 enabled the acquisition of synthetic aperture radar (SAR) imagery in fine-beam mode during the various growth stages of wild rice. SAR data acquired from wild rice life cycles was used to distinguish rice wetlands from other emergent wetlands.

## INTRODUCTION

Wild rice (*Zizania* L.) is an annual aquatic grass that grows in dense continuous stands within shallow clear lakes and rivers throughout eastern and north central North America. Its lighter green color distinguishes it from stands of cattails, bulrush, and other emergent water plants. Wild rice grows from seed each year, with the primary root first to emerge from the germinating seed. Relative to water levels, the life cycle of the wild rice plant involves germination, a submerged stage, a floating leaf stage, and the emergent stages of plant development. Water depth is the primary factor influencing wild rice development. The ideal water depth is about 30 to 60 cm. Deeper water does not allow sufficient light penetration for photosynthesis to occur. Other perennials compete with wild rice, including emergent floating leaf and submerged species (Aiken et al. 1988).

Wild rice has existed in southeastern Manitoba since before European settlement. It was first introduced about 1980 into the northwest-central region of Manitoba. Most of the lakes that were seeded are located in the Flin Flon -The Pas area. The spread of wild rice has been aided by the construction of forest harvesting roads, which allowed for bringing in harvesting equipment and bringing out the harvested rice. About a decade after the introduction of wild rice, a number of conflicts began appearing between the use of some areas for wild rice and other resource use interests. Fisheries managers, in particular, have become concerned with the possible impacts on fish habitat. Wild rice is seeded in shallower bays and along inshore waters of lakes that are typically the most productive habitats for young-of-the-year fish in lakes during the open water period. LANDSAT imagery has been used in the past to monitor wild rice areas in the Flin Flon-The Pas area. The difficulty with LANDSAT is resolution and timeliness of data acquisition.

The objective of this study was to assess the all-weather capability of RADARSAT-1 digital images as a tool for determining the areal extent of wild rice in the boreal forest regions of northern Manitoba.

## SITE DESCRIPTION

The site for this study was located at Kisseynew Lake in northwestern Manitoba between latitudes 54d 55' and 55d 10' north and between longitudes 101d 25' and 102d 10' west. (See Figure 1.) Kisseynew Lake is about 16 km north of the community of Flin Flon and is accessible by road. The lake is approximately 69 km long in an east - west axis. It is a long, narrow lake with the widest expanses at both the east and west ends. The lake constricts into a very narrow area known as Lobstick Narrows. The average depth of the lake is 5.6 m. The area directly east and west of Lobstick Narrows is the largest shallow area of the lake. The geology of the area surrounding Kisseynew Lake is the Precambrian shield, comprised of volcanic, gneissic, quartzite, and granite bedrock. Surficial geology is bedrock controlled with a thin layer of drift, numerous rock outcrops, ridges, knolls, and depressions. Lakes, fens, and bogs occupy depressions.

The surrounding forest cover was the boreal forest region as described by Rowe (1972). Forest cover on the thin-soiled uplands was predominately black spruce (*Picea marina*) with associated jack pine (*Pinus banksiana*). Poorly drained lowland areas were mainly black spruce with associated tamarack (*Larix larcina*). Local areas with favorable soil and microclimate were comprised of mixed stands of white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), trembling aspen (*Populus tremuloides*), and Balsam poplar (*Populus balsamifera*).

## APPROACH

### Data Acquisition

Remotely sensed data was acquired by RADARSAT-1, Canada's first earth observation satellite launched in 1995. It is in a sun-synchronous (dawn-dusk) orbit with a mean altitude of 798 km. The sensor in RADARSAT-1 is a synthetic aperture radar (SAR), which transmits a microwave energy pulse to the area of interest. Unlike optical sensors such as found on LANDSAT, microwave energy penetrates darkness, clouds, rain, dust, or haze, enabling data collection under any atmospheric condition. RADARSAT-1 operates at a single microwave frequency, known as C-band (5.6 cm wavelength). RADARSAT-1 provides 25 possible choices of imagery; each varies with respect to the area covered and the way the earth's surface is viewed.

The RADARSAT-1 swath planner provided by Satellite Acquisition Services (SAS), Canada Center for Remote Sensing, was used to plan the acquisition of imagery. The criteria for acquiring data were to obtain fine-beam imagery during the growth cycle of wild rice. Fine-beam imagery has a nominal resolution of 10 m with coverage of 50 km x 50 km. The swath plan was submitted to the SAS order desk staff who finalized the RADARSAT-1 acquisition plan for submission to the Canadian Space Agency. Three days of imagery were acquired commencing on July 3, 1998, and ending August 27, 1998. (See Table 1.).

### Image Processing

RADARSAT-1 imagery was processed with PCI - EASI/PACE image analysis software. The first step was to generate a histogram of the 16-bit imagery. The purpose for this was to rescale the 16-bit imagery to 8-bit. To classify the wild rice area, an 8-bit image was required by the PCI Imageworks software. An f-gamma three-by-three filter was used to remove high frequency noise (speckle). Three RADARSAT-1 scenes were geocoded and a composite of the three dates was generated. The training area and corresponding signature files were generated for the location west of Lobstick Narrows for all three dates of imagery.

## DISCUSSION AND CONCLUSIONS

The July 3, 1998, RADARSAT-1 image (see Figure 2) was captured during the early emergent stage of wild rice. The emergent rice was about 15 to 20 cm above the surface of the water. Rice will account for a portion of the backscatter with the


**Figure 1. RADARSAT study site location.**

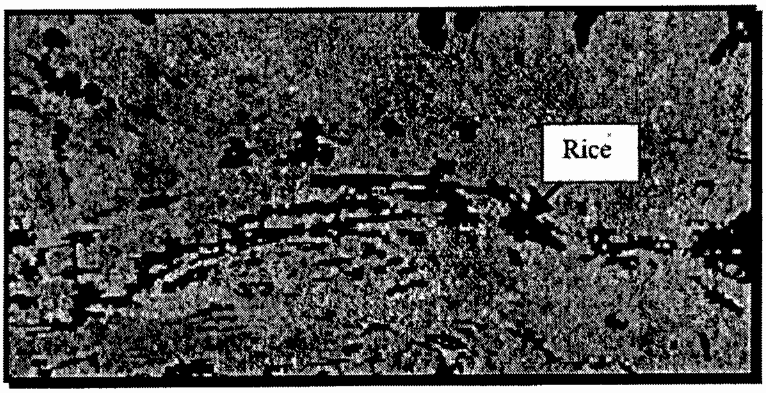


**Figure 2. RADARSAT image on July 3, 1998.**

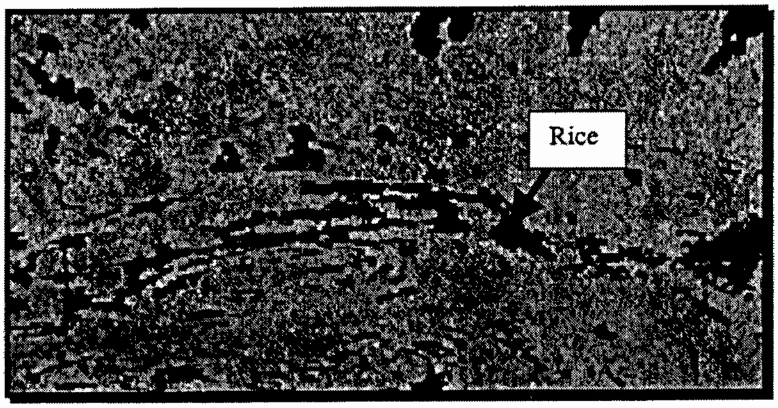


**Figure 3. RADARSAT image on July 10, 1998.**

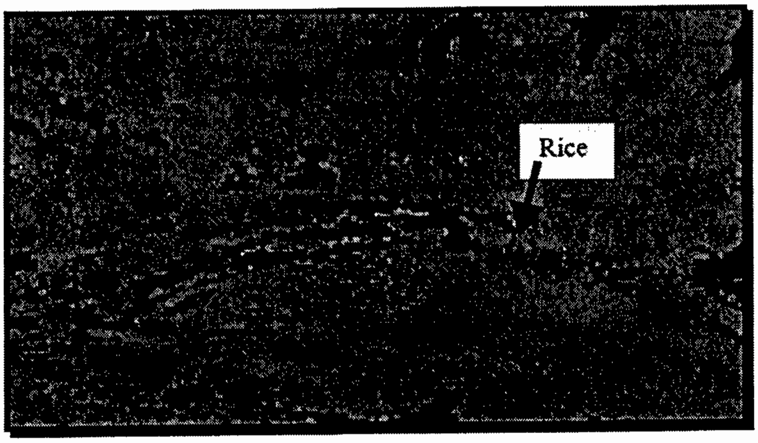


**Figure 4. RADARSAT image on August 26, 1998.**

**Table 1. RADARSAT-1 data acquired for wild rice study.**

| Date | Orbit I.D. | Beam Position |
|---|---|---|
| July 3, 1998 | 13884-Asc. | Fine -5 |
| July 10, 1998 | 13984-Asc. | Fine-3 |
| August 27, 1998 | 14670-Asc. | Fine-3 |

**Table 2. Wild rice signature statistics for three dates.**

| Signature | Mean | Standard Deviation |
|---|---|---|
| Water | 22.71 | 5.65 |
| Rice (July 3,1998) | 24.25 | 6.13 |
| Rice (July 10,1998) | 29.35 | 12.47 |
| Rice (August 27,1998) | 79.41 | 52.87 |

majority of the signature resulting from surface water. (See Table 2.) The July 10, 1998, RADARSAT-1 image (see Figure 3) was captured when the rice was approximately 30 to 40 cm above the surface of the water. The mean and standard deviations are increasing due to the heterogeneity of the signature resulting from the emerging rice. (See Table 2.) The wild rice canopy is apparent and can be easily mapped. The two dates of imagery could give an assessment of wild rice. The August 27, 1998, image (see Figure 4) was captured when the wild rice was in the final aerial emergent stage of the life cycle. The plant stems are approximately 61 to 110 cm in height with a developed flower. The denser the rice canopies, the greater the corresponding backscatter. The signature statistics (see Table 2) for August 27, 1998, training areas demonstrated the increased backscatter values resulting from the rice canopy.

RADARSAT-1 imagery can provide a qualitative and quantitative areal assessment of the wild rice canopy. The imagery can be acquired when needed because clouds and other atmospheric factors will not impede data capture. Two fine-beam images, one captured at the floating leaf stage and one at the mature aerial stage, can be used to determine the boundaries of the wild rice canopy.

## REFERENCES

Aiken SG, Lee PF, Punter D, Stewart JM. 1988. Wild rice in Canada. Agri Can Pub 1830.

Brisco B, Pultz T. 1998. Wetland mapping and monitoring with RADARSAT. In: Proceedings of 20th Canadian Symposium on Remote Sensing; May 10-13, 1998; Calgary, Alberta.

Li C, Brisco B, Brown RJ, Wang J, McDonald J. 1995. SAR/TM wetland identification in the Lake St Clare Delta. In: Proceedings of 17th Can. Sym. on Remote Sensing; June 11-15, 1995; Saskatoon, Saskatchewan.

Rowe JS. 1972. Forest regions of Canada. Can Forestry Serv Pub 1300.

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POSTER/ORAL PRESENTATION

# DISTRIBUTION OF WILD RICE IN MINNESOTA

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## ABSTRACT

Minnesota is generally recognized as including more hectares of wild rice (*Zizania palustris*) than any other state in the United States. The occurrence of wild rice has been historically documented in 45 of Minnesota's 87 counties, including counties in all corners of the state. Anecdotal information suggests an even broader distribution before European settlement. In 1998, the Minnesota Department of Natural Resources (MNDNR) began efforts to document the current distribution of wild rice within the state. Utilizing information from MNDNR wildlife managers and enforcement officers, as well as other federal, tribal, and private sources, the effort has identified more than 600 water basins with significant wild rice stands. This estimated current range of distribution covers at least 55% of the state and includes all but the westernmost and southernmost counties. Work will continue to refine this distribution, including expanded delineation of wild rice stands in riverine systems.

## BACKGROUND

As part of the MNDNR, Division of Fish and Wildlife, Section of Wildlife's continuing efforts to manage waterfowl habitats and natural wild rice stands in Minnesota, an assessment of the current distribution and management efforts relating to this native grain was initiated in 1998 as part of the Section's Wildlife Lakes Program. A final report is not expected until late 2000, but for purposes of this conference, preliminary information on distribution (this paper) and management efforts (Ray Norrgard's paper) will be presented and discussed.

## PROCEDURE

The cornerstones of natural wild rice distribution in Minnesota have been two reports compiled by John B. Moyle of the Minnesota Department of Conservation (now the Department of Natural Resources), Division of Game and Fish, titled "Report on Minnesota Wild Rice for 1940," Fisheries Research Investigational Report No. 22, and "The 1941 Minnesota Wild Rice Crop," Report No. 40. The information in these reports, and other field knowledge from current MNDNR Section of Wildlife staff, were merged with the MNDNR Wildlife Lakes Information System (using Microsoft Access) to compile a preliminary list of natural wild rice lakes that should be reviewed to update the current list of wild rice basins in Minnesota. This list was then sorted and summarized for each MNDNR Wildlife Work Area and sent to its respective field office. Each Area Wildlife Supervisor was then asked to complete information noted under DATA COLLECTED. Also, numerous field interviews were performed with MNDNR Area Wildlife Supervisors and other resource experts to help fill in information needs and gaps. Returned information has been entered into the Wildlife Lakes Information System for data analysis and georeferenced to the MNDNR GIS data set for mapping (using ESRI ArcView).

At the time of this conference, approximately 80% of the requested information has been returned and entered. Since there is still a lot of follow-up needed, all data interpretation at this point is preliminary.

## DATA COLLECTED

For each of the water basins identified on the preliminary list or added through field interviews, the following data were collected:

- estimated total hectares of natural wild rice in the basin of management significance (i.e., the basin is significant because the rice provides important wildlife habitat and/or it has been traditionally harvested);
- who (e.g., MNDNR, USFS, a treaty authority, etc.) manages the water level in the basin, if anyone, and by what means (e.g., beaver dam removal); and
- what type of water control structure (e.g., fixed or variable crest) is used at the outlet of the basin, if any, and who owns it (e.g., MNDNR, highway authority, etc.).

## WILD RICE DISTRIBUTION IN MINNESOTA

The following five distribution maps (and four corresponding data tables) highlight natural wild rice distribution in Minnesota basins (using preliminary information gathered to date).

### General Point (Water Basin) Distribution (Figure 1)

These points have not been scaled to note hectares of wild rice in each water basin and, as such, only represent a general point distribution of water basins with wild rice in Minnesota. As with most aspects of nature, a subtle pattern to this distribution is visible in this figure. The following four maps based on political (e.g., counties and MNDNR Wildlife Work Areas) and ecological boundaries (e.g., watersheds and MNDNR Ecological Classification System Sub-Sections) show various ways to map the current distribution of wild rice in Minnesota.

### Primary Distribution and Area by County (Figure 2; Table 1)

Primary distribution and top-five ranking of natural wild rice basins in Minnesota as determined by a sum of total wild rice hectares estimated per basin on a county basis are: 1) St Louis, 23,208 hectares; 2) Cass, 20,326 hectares; 3) Itasca, 19,246 hectares; 4) Aitkin, 12,827 hectares; and 5) Crow Wing, 9860 hectares. These counties are all contiguous and exist in the north central to northeastern parts of Minnesota. The county distribution map represents 85,467 hectares or 57% of total statewide inventoried wild rice hectares.

### Primary Distribution and Area by Watershed (Figure 3; Table 2)

Primary distribution and top-five ranking of natural wild rice basins in Minnesota as determined by a sum of total wild rice hectares estimated per basin on a watershed basis are: 1) Mississippi River (headwaters segment), 14, 188 hectares; 2) Big Fork River, 11,757 hectares; 3) Mississippi River (Grand Rapids segment), 11,327 hectares; 4) Leech Lake River, 11,318 hectares; and 5) Mississippi River (Brainerd segment), 10,833 hectares. These watersheds are all contiguous and exist in the north central to northern parts of Minnesota. The watershed distribution map represents 59,423 hectares or 39% of total statewide inventoried wild rice hectares.

### Primary Distribution and Area by MNDNR Ecological Classification System Sub-Section (Figure 4; Table 3)

Primary distribution and top-five ranking of natural wild rice basins in Minnesota as determined by a sum of total wild rice hectares estimated per basin on a ECS Sub-Section basis are: 1) Chippewa Plains, 34,563 hectares; 2) Pine Moraines and Outwash Plains, 31,520 hectares; 3) Mille Lacs Uplands, 19,155 hectares; 4) Border Lakes, 17,480 hectares; and 5) Nashwauk Uplands, 15,163 hectares. While these sub-sections show the same north central to northeast distribution in Minnesota, they are not contiguous and show a break in this distribution based on the existence of the St Louis Moraine ECS Sub-Section between the north central and northeast range distributions. The ECS Sub-

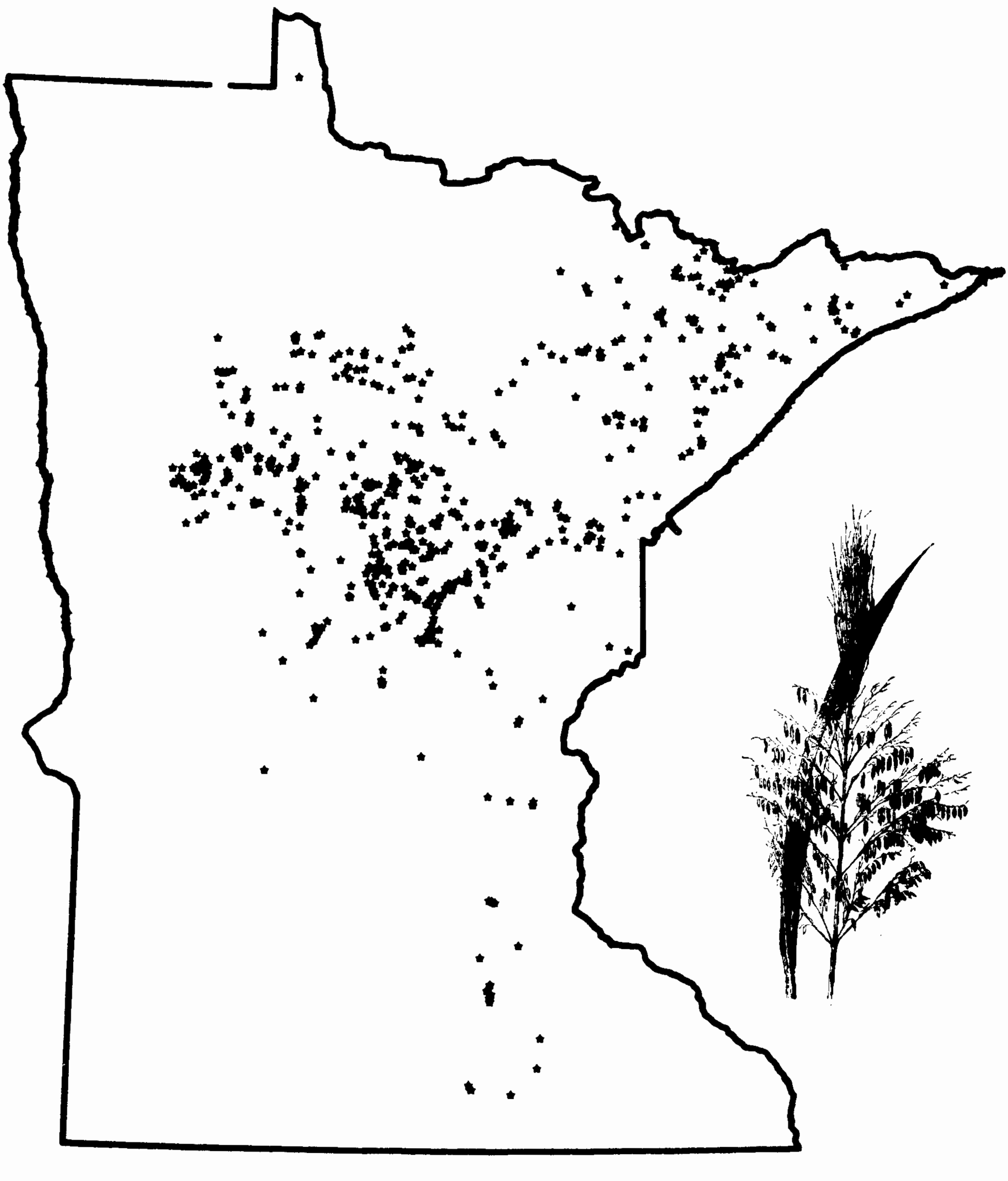

**Figure 1. General point distribution of natural wild rice basins in Minnesota.**

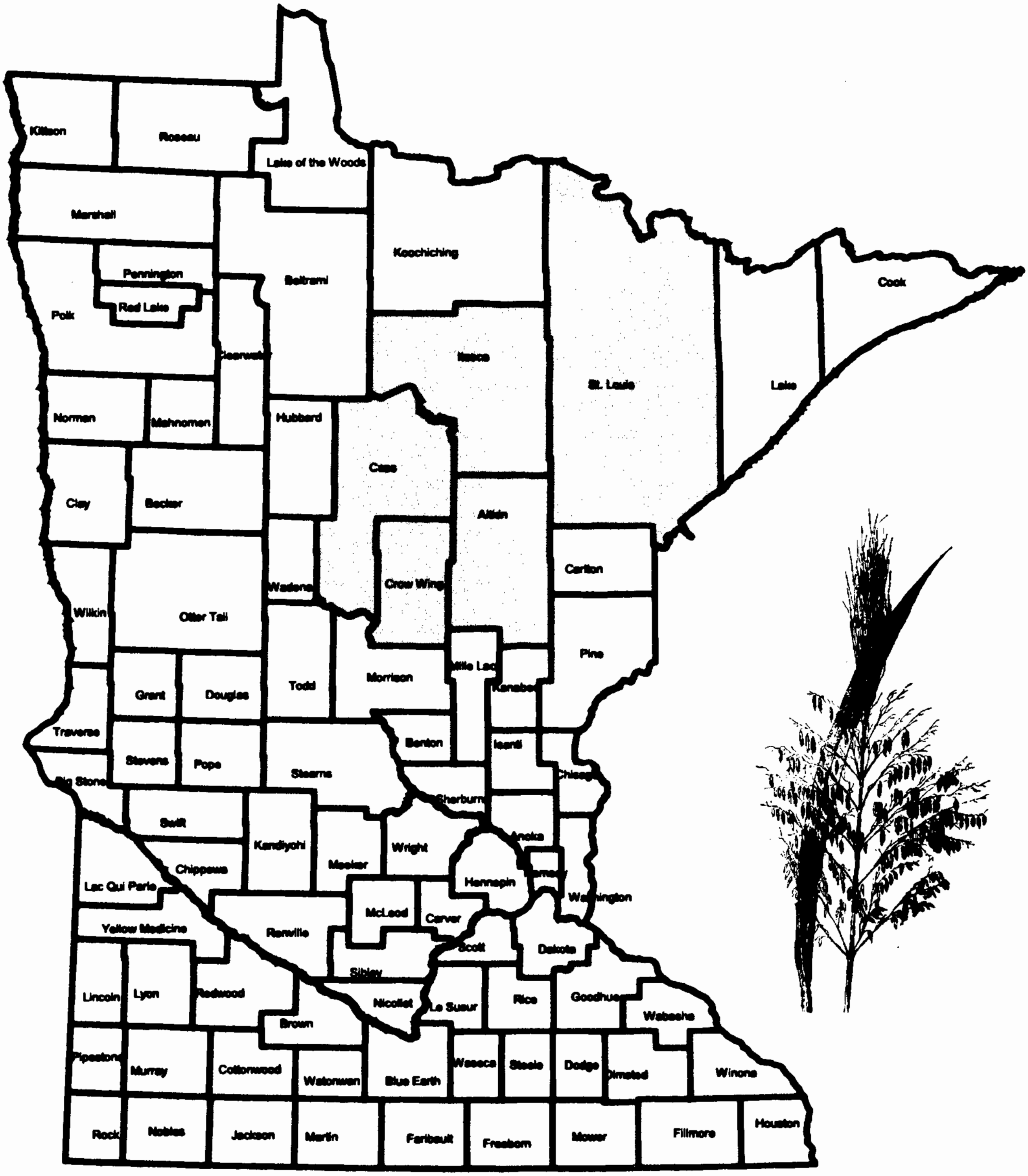


**Figure 2. Primary distribution of wild rice in Minnesota as demonstrated by total hectares in top-five ranking counties.**

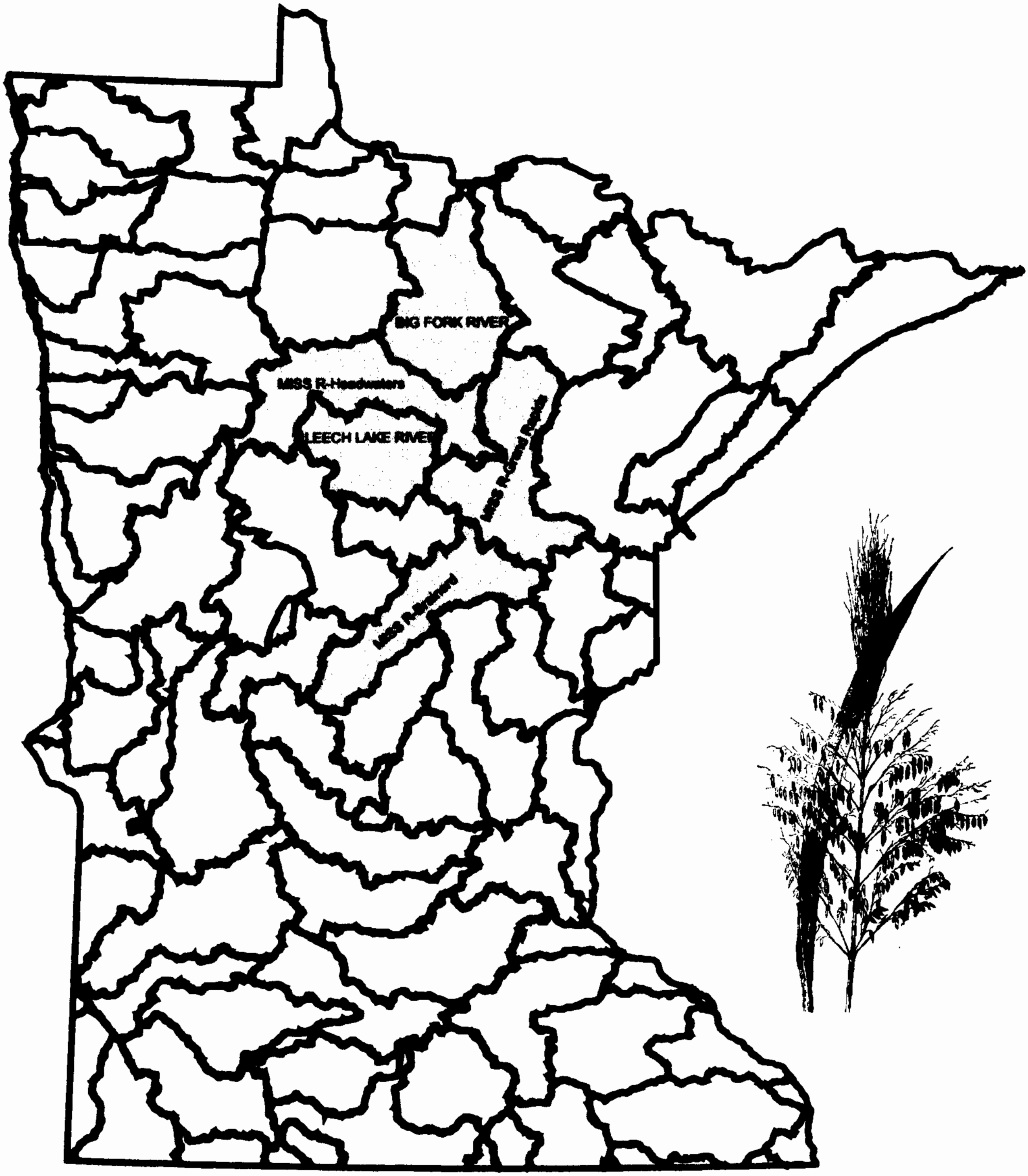


**Figure 3. Primary distribution of wild rice in Minnesota as demonstrated by total wild rice hectares in top-five ranking watersheds.**

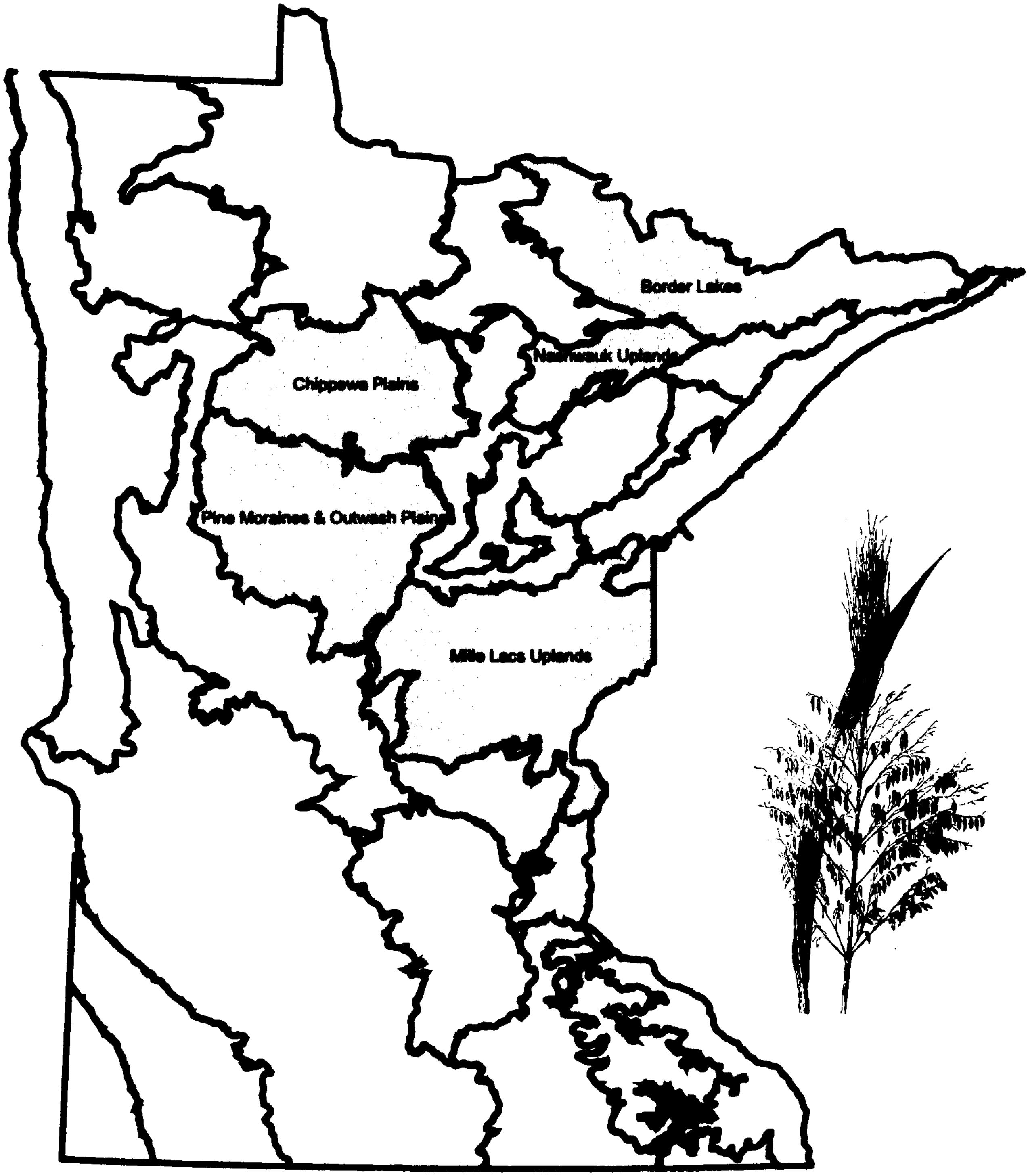


**Figure 4. Primary distribution of wild rice in Minnesota as demonstrated by total wild rice hectares in top-five ranking ECS Sub-Sections.**

**Table 1. Wild rice basins and area by county.**

| *County* | Number of Basins | Basin Hectares | Wild Rice Hectares |
|---|---|---|---|
| *Aitkin* | 64 | 86,329 | 12,827 (14.8%) |
| *Cass* | 67 | 558,768 | 20,326 (3.6%) |
| *Crow Wing* | 87 | 98,551 | 9,860 (10%) |
| *Itasca* | 28 | 102,673 | 19,246 (18.7%) |
| *St Louis* | 77 | 236,680 | 23,208 (9.8%) |
| *Other (26 counties)* | 293 | 2,682,813 | 64,672 (2.4%) |
| **TOTAL statewide** | **616** | **3,765,814** | **150,139** |

**Table 2. Wild rice basins and area by watershed.**

| *Watershed* | Number of Basins | Basin Hectares | Wild Rice Hectares |
|---|---|---|---|
| *Big Fork River* | 5 | 32,574 | 11,757 (36%) |
| *Leech Lake River* | 38 | 333,606 | 11,318 (3.4%) |
| *Mississippi River (Brainerd segment)* | 67 | 61,293 | 10,833 (17.7%) |
| *Mississippi River (Grand Rapids segment)* | 44 | 63,842 | 11,327 (17.7%) |
| *Mississippi River (Headwaters segment)* | 40 | 274,866 | 14,188 (5.2%) |
| *Total of all other watersheds (33)* | 422 | 3,007,042 | 90,696 (3%) |
| **TOTAL statewide** | **616** | **3,773,223** | **150,119** |

Section distribution map represents 117,811 hectares or 78% of total statewide inventoried wild rice hectares.

**Primary Distribution and Area by MNDNR Wildlife Work Area (Figure 5; Table 4)**

Primary distribution and top-five ranking of natural wild rice basins in Minnesota as determined by a sum of total wild rice hectares estimated per basin on a MNDNR Wildlife Work Area basis are: 1) Grand Rapids, 34,973 hectares; 2) Eveleth,16,811 hectares; 3) Brainerd, 15,015 hectares; 4) Bemidji, 14,089 hectares; and 5) Aitkin, 12,814 hectares. These MNDNR Wildlife Work Areas are all contiguous and show the same dominant north central distribution of wild rice in Minnesota. The MNDNR Wildlife Work Area distribution map represents 93,702 hectares or 50% of total statewide inventoried wild rice hectares.

## CONCLUSION

While the preliminary distribution maps and area figures provide some interesting graphics and future discussion points, the long-term purposes of this effort are to:

- design, create, and maintain a statewide wild rice database/GIS component to the

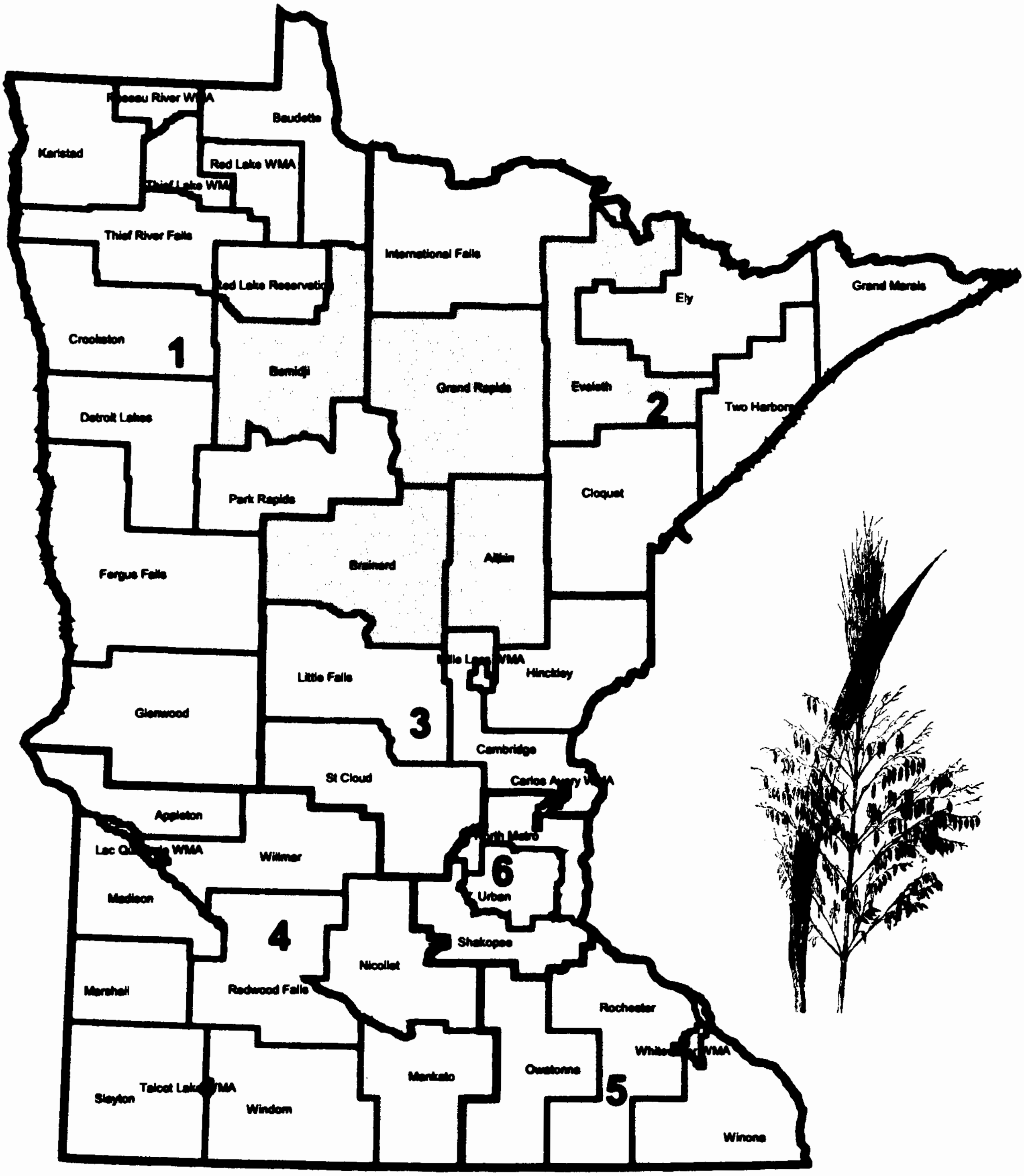


**Figure 5. Primary distribution of wild rice in Minnesota as demonstrated by total wild rice hectares in top-five ranking MNDNR Wildlife Work Areas.**

**Table 3. Wild rice basins and area by MNDNR Ecological Classification System (ECS) Sub-Section.**

| *ECS Sub-Section* | Number of Basins | Basin Hectares | Wild Rice Hectares |
|---|---|---|---|
| *Border Lakes* | 51 | 244,804 | 17,480 (7%) |
| *Chippewa Plains* | 56 | 570,190 | 34,563 (6%) |
| *Mille Lacs Uplands* | 103 | 94,265 | 19,155 (20%) |
| *Nashwauk Uplands* | 42 | 31,744 | 15,163 (48%) |
| *Pine Moraines and Outwash Plains* | 198 | 258,947 | 31,520 (12%) |
| *Total of all other ECS Sub-Sections (12)* | 166 | 2,573,273 | 32,258 (1%) |
| **TOTAL statewide** | **616** | **3,773,223** | **150,139** |

**Table 4. Wild rice basins and area by MNDNR Wildlife Work Area.**

| *MNDNR Wildlife Work Area* | Number of Basins | Basin Hectares | Wild Rice Hectares |
|---|---|---|---|
| *Aitkin* | 63 | 86,255 | 12,814 (14.8%) |
| *Bemidji* | 37 | 59,460 | 14,089 (23.6%) |
| *Brainerd* | 122 | 153,187 | 15,015 (9.8%) |
| *Eveleth* | 29 | 63,133 | 16,811 (26.6%) |
| *Grand Rapids* | 46 | 309,659 | 34,973 (11.2%) |
| *Total all other MNDNR Wildlife Work Areas (42)* | 319 | 3,101,530 | 93,702 (3.0%) |
| **TOTAL statewide** | **616** | **3,773,224** | **187,404** |

MNDNR Section of Wildlife's Wildlife Lakes Information System;

- finalize current distribution maps and related summaries of wild rice in Minnesota based on political and ecological units;
- provide an informational link for all wild rice management efforts in Minnesota; and
- act as a stimulus for the stewardship of this vital aquatic natural resource as a critical and integral part of overall lake management efforts in Minnesota.

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# REINTRODUCTION POTENTIAL OF TEXAS WILD RICE (*ZIZANIA TEXANA*) INTO THE SAN MARCOS RIVER, TEXAS

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Paula Power
Kathryn Kennedy

## ABSTRACT

Texas wild rice is an endangered aquatic macrophyte species endemic to the upper portions of the San Marcos River, Texas. This species is one of only two recognized perennial forms of wild rice and is found exclusively in the first 2.4 km of this thermally constant, spring-fed river. The plant has long ribbon-like leaves up to 2 m in length and commonly grows in small dense clumps in the faster flowing sections of the river. Historic data indicate that the population has declined precipitously during the past century. Since the plants cannot self-pollinate, the current population level may be too low and widely dispersed to allow effective replenishment of the species by natural seed formation. Recovery of the species may be further threatened by *Hydrilla verticilata* and *Hygrophyla polysperma*, two nuisance exotic species that have expanded in distribution within the San Marcos River and currently occupy much of the area once thought to be covered by wild rice. Finally, the species is threatened by unusual hydrologic conditions (droughts and floods) that have occurred during the past few years. Efforts are now underway to expand the limited distribution of the species within its natural range. This paper will provide an overview of the threats to the species as well as present specific methods utilized for re-introduction of the species to the river. Initial results of the reintroduction efforts will be presented.

## TEXAS WILD RICE ECOLOGY

Texas wild rice (*Zizania texana*) is an endangered aquatic grass known only in the upper 2.4 km of the San Marcos River in Hays County, Texas. The San Marcos River is fed by springs flowing from the Edwards Aquifer. Within the reach of the river occupied by Texas wild rice, the water temperature and chemical composition is very constant throughout the year (Groeger et al. 1997).

Unlike the more common and widely distributed *Zizania aquatica* and *Zizania palustris*, Texas wild rice appears to have two distinct growth forms: a long-lived evergreen perennial submersed form and an emergent short-lived form (Terrell et al. 1978; Power and Doyle personal observation). As such, this unusual species is the only North American wild rice species to have a perennial existence. Although rigorous experimental evidence is lacking, Texas wild rice appears to exhibit the long-lived perennial life characteristic only when submersed in the flowing water of the San Marcos River. In its natural river habitat, Texas wild rice forms 20 to 50 cm diameter individual clumps of long, ribbon-like submerged leaves. These clumps then form emergent culms that are capable of both sexual and asexual reproduction. The emergent portion of the culms have a terminal, wind-pollinated inflorescence. Beneath the water surface, these culms may develop into tillers (asexual clones) by the growth of adventitious roots at one or more nodes. More complete descriptions of the species when growing in the river are provided by Terrell and others (1978) and Vaughan (1986).

Under greenhouse or low-flow raceway culture conditions, Texas wild rice grows primarily emergent and appears to be a short-lived annual (Terrell et al. 1978; Power personal observation). Under culture conditions, the plant produces few true submersed leaves, and the vast majority of the biomass is emergent. The plant flowers and produces viable seed. Again, while experimental data are lacking, these cultured plants appear to be relatively short-lived and may often die after seed production (Power, personal observation). When deliberately planted in shallow, low-flow environments within the river system, the plants exhibit the emergent growth form (Power, unpublished data).

The habitat preferences of Texas wild rice within the river have been investigated by comparing the physical and chemical features of transects containing wild rice plants and transects lacking wild rice (Poole and Bowles 1999). Results of this survey indicate that the species is found in reaches that are shallow (< 1 m), with coarse substrate, and having relatively rapid flow. Other variables measured (pH, temperature, dissolved oxygen, and conductivity) did not vary between rice and non-rice transects. Experimental evidence provides fundamentally similar conclusions (Power 1996a and 1996b).

As mentioned above, when cultured in greenhouse tanks or outdoor raceways, Texas wild rice readily flowers and produces seed. However, in the wild, seeds are rarely produced. As a result, wild plants have been limited to asexual reproduction over the past decade or more. When produced, the seeds are viable, and germination is affected by oxygen concentration and sediment texture (Power and Fonteyn 1995).

Ongoing research indicates that the submersed leaves of Texas wild rice are obligate $CO_2$ users and cannot utilize $HCO_3$ from the water environment (Power and Doyle, unpublished data). This is normally not a problem in the spring-fed river because the waters of the river are characteristically supersaturated in $CO_2$ as they emerge from the underground aquifer. Given the relatively high alkalinity and circumneutral pH of the water, $CO_2$ availability should be high throughout the upper reaches of the San Marcos River.

Although historically abundant within its limited range, Texas wild rice showed a dramatic population decline between about 1940 and 1965 (Emery 1967). By 1976, the total abundance of Texas wild rice within the river was about 1100 $m^2$ (Emery 1977). Recent surveys of the aquatic plant community of the San Marcos River indicate that the total distribution of the species has not changed much from this value and has fluctuated between 1400 and 1600 $m^2$ since 1994 (Texas Parks and Wildlife Department unpublished annual survey data; Doyle, unpublished data).

## CURRENT THREATS FACING TEXAS WILD RICE

Numerous threats currently face this unique endangered plant species within the San Marcos River. Many of these threats were first identified by Emery (1977) and remain as much a problem today as then. These threats include (but are not limited to) variable hydrology, herbivory, human impacts, and competition from aggressive non-native plants (U. S. Fish and Wildlife Service, 1994).

### Variable Hydrology

Droughts and floods both appear to have negatively impacted Texas wild rice over the last few years. Due to low rainfall and the resultant low flows from the springs, the water levels within the river have fallen to unusually low levels several times during the past years. During some of these low-flow periods, some stands of Texas wild rice have been exposed to desiccation and have died. Continued declines in the groundwater supply of the Edwards Aquifer by pumping may further threaten the long-term survival of the species, especially if a prolonged drought were to occur.

More recently, floods have also contributed to the loss of the species. In October 1998, there was a major flood in the river. Water levels rose to more than 7 m above flood stage. The flood was the second largest flood on record. Monitoring of the Texas wild rice distribution shows that declines of up to 50% in some reaches of the river occurred, while other reaches showed more modest declines of only 20% (Doyle, unpublished data). The annual Texas wild rice survey throughout the entire upper reach of the San Marcos Rives is being conducted this summer by the Texas Parks and Wildlife

Department and should provide more complete information on the impacts of the flood.

## Herbivory

Not surprisingly, Texas wild rice is subject to herbivory pressures. Waterfowl are commonly observed eating the emergent culms of the plant, thereby making in situ seed production quite difficult. However, in addition to having the flowers and seeds eaten, numerous species actually eat vegetative portions of the plant itself. Nutria and turtles (especially red-eared pond sliders) eat mature plants while crayfish have been suspected of damaging developing seedlings. Although the total impact of herbivory on the species is not known, it seems that with the very restricted distribution of the plant species that now occurs, all of these threats must be considered significant. It is likely that Texas wild rice, like most aquatic plant species, could tolerate substantial levels of herbivory if the population were more abundant. Experimental plantings in Spring Lake, at the headwaters of the San Marcos River, in the early 1990s, resulted in extensive loss of transplants due to herbivory when not protected by exclosures (Power 1996c).

## Human Impacts

Because of the location of the river within the city of San Marcos and the enormous use of this spring-fed river for recreation, the damage to the population by direct human impact may be substantial. Emery (1967) identified human impacts as one of the more likely reasons for the dramatic decline of the species. Fortunately, some of the more obvious types of human disturbances such as periodic plowing of the river bottom by city workers and removal of native vegetation in order to plant exotic aquatic plants to supply commercial home aquaria demands, which were cited by Emery in 1967, are no longer taking place. However, many more subtle impacts still occur.

Recreational use of the river clearly impacts the plants. This is especially true when the plant makes emergent reproductive stalks. Since this emergent vegetation interferes with tubing and swimming, many people may simply pull the "seaweed" out to "improve" the river. Experimental evidence suggests that even if the plants are not pulled out, the simple act of being repeatedly submersed by swimmers and tubers will likely decrease the effectiveness of seed production (Power 1997).

Indirect human impacts such as nutrient enrichment (leading to dense epiphyte coatings on the submersed leaves), herbicides (resulting in direct mortality), and increased sediment runoff (reducing water clarity) are also likely of importance. While the impact of these factors on Texas wild rice have not been directly evaluated in this river, there is ample evidence from other rivers that this is likely to be a major concern.

## Competition from Nuisance Non-Native Plants

While the distribution of Texas wild rice has declined, the abundance of some nuisance exotic species has dramatically increased over the years. *Hydrilla verticillata* (hydrilla) in particular is a problem. This pest species was introduced to the United States during the 1960s and has since become one of the major threats to the ecology of freshwater environments in this country. In the San Marcos River, hydrilla now is the most abundant species in the river (Doyle, unpublished data).

Texas wild rice may be relatively more resilient than some other species to resisting invasion by hydrilla. Poole and Bowles (1999) observed that the hydrilla abundance did not exceed 29% in wild rice transects but averaged nearly 47% in non-rice transects. Even so, we have observed negative impacts of hydrilla on Texas wild rice. We have observed small hydrilla populations start to grow in the open spaces among the wild rice clumps. As the hydrilla plants develop, they rapidly elongate to the surface and slowly engulf downstream clumps of Texas wild rice. When the hydrilla is removed, the plants beneath are yellowed.

In addition, when harvesting methods are used to attempt to control hydrilla, the fragments that float downstream threaten Texas wild rice. Rafts of plant fragments (largely hydrilla) often get tangled in the emergent stalks of Texas wild rice and effectively shade the rooted plants beneath (Power 1996d). When these rafts are removed, the Texas wild rice plants beneath appear yellowed and unhealthy.

## EFFORTS TO ENHANCE DISTRIBUTION OF TEXAS WILD RICE

Collaborative efforts among the U. S. Fish and Wildlife Service, the U. S. Army Corps of Engineers Waterways Experiment Station, and the University of North Texas are underway to develop methods that would allow managers to enhance the distribution of Texas wild rice and other beneficial native species in the river.

Ongoing studies to date include a preliminary planting density experiment utilizing Texas wild rice transplants and a field establishment study utilizing surrogate native plant species. Preliminary evaluations of these experiments are given below.

### Planting Density Experiment

A pilot density experiment was initiated in July 1998 near the Interstate 35 crossing of the San Marcos River. Plants for this experiment were raised in flowing water raceways fed with aquifer water located on the grounds of Southwest Texas State University (SWTSU). Plants were grown from seed in 10-cm biodegradable peat pots for several weeks prior to being transported to the San Marcos River. Plants were planted in clusters of three densities: 1, 4, and 9 plants per cluster. In the 4- and 9-plant clusters, the individual plants were separated from each other by about 15 cm. Four blocks containing all planting densities were planted. Prior to planting, the number of culms and leaves of each plant were counted. We attempted to select neighboring sites with similar depths and flows but lacking other vegetation. However, two of the blocks had hygrophila (*Hygrophila polysperma*) or hydrilla growing nearby. After four weeks of growth in the field, the plantings were evaluated. The number of leaves and culms of each plant were counted to compare to that present at the beginning of the experiment as a measure of plant growth.

After this four-weeks growth period, 44 of the original 56 plants were still alive. The plants that did not survive were mostly plants that had no other vegetation growing around them. Many of the surviving plants exhibited characteristic crayfish damage to the leaves. Survival and growth did not appear to be a function of the original planting density. However, the plants that showed significant gain in leaf and culm numbers where those that were surrounded by other vegetation, indicating a potential "nurseplant" effect. Unfortunately, the major flood of October 1998 washed away all but one of the surviving plants, and further evaluations were not possible.

### Field Establishment Study

Test plantings utilizing surrogate species were initiated in the summer of 1998. During this time, plantings were made of *Sagittaria platyphylla*, *Ludwigia repens*, and *Vallisneria americana*. Plants were initially collected from the San Marcos River and cultured for 8 weeks in the raceways at SWTSU for 8 weeks. By the time of transplant to the field, the plants were well-established and actively growing. Sixty-two transplants of *Vallisneria* and 50 each of *Sagittaria* and *Ludwigia* were planted in the river in July 1998. Plantings for each species were made in pairs. The roots of one plant of each pair were covered with a small piece of plastic wire mesh and secured to the sediments with a plastic sediment anchor. We hoped that this anchoring system would keep the plants from being washed out of the sediment prior to establishment and also provide a measure of protection in the event of herbivory. Although the leaves and stems of the plants might be grazed, the roots would be protected below the wire mesh and hopefully regrow. The second plant in each pair had only the plastic sediment anchor driven through the root mass to help secure the plant to the substrate.

Preliminary evaluation of the plantings in September 1998 indicate that most *Vallisneria* plants failed to survive. This species seems to grow much more slowly than the other two and may not have been as well established following the 8-week culture period as the other two species. The *Sagittaria* plants looked particularly vigorous but did not seem to benefit from the additional protection afforded by the screens. The *Ludwigia* plants were the only ones that benefited from the screens and survived well. Unfortunately, the flood of October 1998 destroyed most of these plantings and prevented more rigorous evaluation of the results. Even so, many of the *Sagittaria* plants initially planted survived the floods and now form small but expanding populations.

Recently, additional plantings were made in the river to evaluate the growth potential of *Sagittaria*. Twelve dozen plants were planted in the river in early May 1999. The plants all utilized a plastic sediment anchor but did not have the plastic wire meshes because earlier data indicated this did not improve survival rates for this species. These plants were evaluated after 6 weeks of growth; only 9 of the 144 plants were not found (presumed dead). Of the remaining plants, 77 were rated as "excellent," indicating vigorous growth since planting.

## FUTURE RESEARCH

Plans for further field research this summer include repetition of the wild rice density planting experiment and continued monitoring of the surrogate plantings. In the future, we will evaluate the advisability of implementing a broader field establishment effort.

## REFERENCES


Emery WHP. 1967. The decline and threatened extinction of Texas wild-rice (*Zizania texana* Hitchc). Southwestern Naturalist 12(2):203-4.

Emery WHP. 1977. Current status of Texas wild rice. Southwestern Nat 22:393-4.

Groeger AW, Brown PF, Tietjen TE, Kelsey TC. 1997. Water quality of the San Marcos River. Texas Journ of Sci 49(4):279-94.

Poole J, Bowles DE. 1999. Hatibat characterization of Texas wild-rice (*Zizania texana* Hitchcock), an endangered aquatic macrophyte from the San Marcos River, TX, USA. Aquatic Conserv: Mar Freshw Ecosyst 9:291-302.

Power P. 1996a. Effects of current velocity and substrate composition on growth of Texas wild-rice (*Zizania texana*). Aquatic Botany 55:199-204.

Power P. 1996b. Growth of Texas wild-rice (*Zizania texana*) in three sediments from the San Marcos River. Journ of Aqua Plant Management 34:21-23.

Power P. 1996c. Reintroduction of Texas wild-rice (*Zizania texana*) in Spring Lake: Some important environmental and biotic considerations. In: Proceedings from 2nd Southwestern Rare and Endangered Plant Conference; Rocky Mtn Forest and Range Exp Sta; Sept 11-14, 1985; Flagstaff, Ariz.

Power P. 1996d. Direct and indirect effects of floating vegetation mats on Texas wild-rice (*Zizania texana*). Southwestern Naturalist 41(4):462-4.

Power P. 1997. Moisture, seeds, and reproductive failure in Texas wild-rice (*Zizania texana*). Southwestern Naturalist 42(4):435-40.

Power P, Fonteyn PJ. 1995. Effects of oxygen concentration and substrate on seed germination and seedling growth of Texas wild-rice (*Zizania texana*). Southwestern Naturalist 40(1):1-4.

Terrell EE, Emery WHP, Beaty HE. 1978. Observations on *Zizania texana* (Texas wild-rice), an endangered species. Bulletin of the Torrey Botanical Club 105:50-7.

U. S. Fish and Wildlife Service. 1994. Draft San Marcos/Comal (Revised) Recovery Plan.

Vaughan EJ Jr. 1986. Population and autecological assessment of *Zizania texana* Hitchc. (Poaceae) in the San Marcos River [MS Thesis]. Southwest Texas State Univ.

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